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Evening Meeting.

Monday, May 3rd, 1875.

MAJOR-GENERAL PATRICK L. McDOUGALL, Deputy Quarter-Master General (Intelligence Branch), in the Chair.

NAMES of MEMBERS who joined the Institution between the 27th April and 3rd May, 1875.

ANNUAL.

Smyth, E. G. Selby, Lieutenant, 86th Regiment.
Wyatt, Harry F. J., Lieutenant, R.N.
Woodrow, Alex. K., Lieutenant, R.N.

ON THE ORGANIZATION OF THE COMMUNICATIONS OF AN ARMY, INCLUDING RAILWAYS.

By Lieutenant-Colonel R. HOME, C.B., R.E., D.A.Q.M.G.

THE subject upon which I am going to address you this evening is a dry one, but its importance is so great, that I feel it requires no apology for being introduced; although I feel that I should apologise for presuming to deal with so large and so complicated a question.

When I was asked to give a lecture at this Institution, I looked through the various subjects that had recently been brought forward, and I found that no one had taken this special subject up. Feeling deeply impressed with its importance, I determined to try and read a paper on it, hoping that other and more competent persons may be induced to follow my lead. Our language is not rich in military terms, and the expression, *the organization of the communications of an army*, is a clumsy one to express what the Germans call "*etappen*"—a word which they have taken from the French *étape*. I know of no English term which expresses what is meant, and therefore I have used a term

which was adopted during the Peninsular, our greatest war, for nearly the same thing. By the words, "the organization of the communications of an army," is meant, therefore, not the maintenance or repair of roads, railways, canals, or telegraphs, so much as the organization which enables an army to obtain the greatest benefit from those means of communication.

When an army advances into a hostile country, it has to be supplied with food, ammunition, and other stores; it has to receive reinforcements in men and horses from the rear; and it has to send back sick or wounded men and horses from the front. If an army of moderate size, say 50,000 men, simply marches 100 miles, without firing one shot, or seeing an enemy, the number of sick that have to be got rid of is very great. Experience has shown that, in a good climate, with abundant food, easy marches, and fair weather, the waste from ordinary causes in a ten days' march of such a force would be between 2,000 and 2,500 men, while the number of galled, foot-sore, or worn-out horses would also be very large. A few wet days or a sharp engagement would raise the number of both very considerably. An inefficient man or horse at the front is a positive disadvantage; he can do no work, and he consumes food which is difficult to get, and often occupies the time of a sound man by requiring to be looked after; consequently, if an army is to be kept efficient in front, there must be a stream of men and horses passing along the lines of communication from the base of operations in the rear to supply the waste in front, and a succession of depôts where sick men and horses may be tended, cured, and again sent to the front.

Further, an army must be fed, and the magnitude of the operation is what many people rarely consider. The action of an army in the field, its marches and its battles, the lists of killed or wounded are what chiefly strike the eye of the looker on; when a man is killed or wounded, or even when he is taken prisoner, his loss is chronicled; but the man is just as much lost if he dies or is invalided from want of food or medical aid. We read of so many killed, wounded, and prisoners, and of so many guns and standards captured; but who notices the losses from privations and hardships? Yet the losses from the latter causes far outweigh those from the former. We read much of the fight at Magenta and the battle of Solferino. Volumes have been written in which you will find accounts of both in the greatest detail; but we rarely see an account of the suffering endured by the French Army from the 9th to the 17th June, 1859; during the first few days the troops were ordered to live on the peasants, and latterly, although in a friendly country, the order was repeated, with the words added, "even to complete exhaustion"—words never used except in the direst extremity.

We read much of the battles round Metz: of the gallant conduct of the soldiers of two great nations; of the skill displayed by the Generals on this side, of the mistakes made by those on that. We read long lists of killed and wounded, but we hear little of the many human lives lost by fever, cold, hunger, and want round, the beautiful city of Lorraine.

Few realize the fact that an army requires as much food as a very

large city. Each day a large city receives its daily supply of food, there is no stint nor stay for those who can purchase; long custom and gradual improvements have opened up easy means of communication between the consumer and the producer. It is different with an army. An army is a city flung down suddenly in the country, each day moving, each day requiring fresh alterations in the arrangements by which food is conveyed from the producer to the consumer. Yet this portion of the art of war—one of the most important, if not *the most important*—receives but scant notice. "War is the art of being the strongest at any given place," and that portion of the art of war that keeps the greatest number of bayonets in the ranks, is surely not to be despised.

It is often asked, why this difficulty about food? The number of mouths in a country is but slightly increased when two armies meet; the total number of mouths in the two countries at war is really diminished. Why then this difficulty? The answer lies here. Suppose there are 10,000 bakeries in England, an addition of ten mouths to be fed by each would make but a slight difference, if distributed. But suppose the additional 100,000 mouths all concentrated in one place, and requiring to be fed all at once, the circumstances are altered.

There are really but three ways by which, or by modifications of which, armies can be fed in the field:—

1st. The soldiers may obtain food by being billeted on the inhabitants, or by living from hand to mouth as they march.

2nd. The whole of the provisions may be carted after the army.

3rd. The army may be fed from magazines.

Let us consider these three methods. In the first case, the army would soon cease to be a military body; the men would quickly become a mob of marauders, and cease to be an army. In a thinly peopled country, moreover, the dispersion of the men in search of food would be so great that little or no progress to the front could be made, and the moment a halt took place, the troops having exhausted the district where they were, would simply starve, precisely as a bullock tethered by a string will eat up everything in its circle and, if not moved, die from starvation, even in the midst of a rich meadow. This was the system generally adopted by the great Napoleon; it is one which we do not read much about in ordinary military histories, and into which we only get an insight by reading personal narratives of the wars at the beginning of this century. And it must be confessed, that the genius of Napoleon as a strategist and tactician appears all the more marvellous when the system under which he made war is considered. The marches made by the French Army Corps to blockade Ulm were made in this manner, and French writers say the men suffered severely for many days. Pillage showed itself in that, the finest army Napoleon ever commanded. This must be the invariable result of there being no magazines. A victorious army may march on a broad front in a rich country in such a way, but the moment it concentrates to fight, or halt, it is plunged into the greatest difficulties.

After the capture of Berlin in 1808, when the French undertook the winter campaign in Poland, their sufferings were very great; whole

corps disappeared, broken up into bands of marauders seeking food in the scattered farms of that inhospitable country.

The serious check received by the French Army at Eylau, was caused by the demoralisation consequent on this system. The resources of a country cannot be utilised by an army marching through it; they are wasted and lost.

We now turn to the second method, that by which an army is fed by provisions carried with it on waggons; this is possible for a very small force, but for a force of any magnitude it is impossible.

The Comte de Paris has furnished a remarkable calculation on this subject. He says, one road will suffice for only a limited number of carriages; if several roads are available, the number of waggons must be limited, otherwise the army cannot move.

A six-horse waggon will carry 2,000 lbs.; and the supply for each man per day, medical stores, ammunition and food included, may be placed at 4 lbs. per man.

Such a waggon will supply 500 men for one day; but if the army is a day's march from its base, it will only supply 250 men, for it must go back empty to re-fill at the base. If it is two days from its base, 4 waggons for 500 men are requisite, or 8 per 1,000, or 800 waggons for 100,000 men. But if the army of 100,000 men, includes as it would do, 16,000 cavalry and artillery horses, 200 waggons would be requisite to carry a day's forage, or 800 if the army was two days march from its base; or 1,600 waggons, horsed with 9,600 horses, but these waggons would be three days away from the base and one day there, consequently they would require 360 more waggons, horsed by 2,460 animals, to feed them; these would require 92 additional waggons, and so on, until we arrive at a total of 2,000 waggons, horsed by 12,000 animals, as being absolutely requisite to feed an army of 100,000 men two days from its base of operations. If the army advances one day further, or three days march from its base, it would require 3,760 waggons, horsed by 22,000 animals, a column 38 miles long if the intervals could be kept; but which would extend over 48 miles or the whole four marches; and even this number of waggons does not give a true picture, for there must be a fresh set of waggons to carry the food from the divisional depôts to the regiments. To move ten days from the base of operations, on the basis furnished by the Comte de Paris, would require 10,975 waggons, horsed by 65,850 horses. This is a number which it would be practically impossible to deal with, covering no less than 108 miles if the distances be kept, but which would really be more than the whole length of the ten days march.

The third method, or that of magazines, is consequently the only sure, safe, and possible means of making war, provided it be judiciously combined with a system of requisitions.

Along the roads, railways, or canals forming the line of communication of an army, there must be two distinct streams always flowing, viz., that which supplies the army with fresh or convalescent men and horses, as well as food and warlike stores of all kinds (this stream flows from the base to the army), and that flowing in the opposite direction, which carries back sick and wounded men, horses, and

prisoners, either to depôts on the line of communication, or to the base itself, and also the empty waggons returning for fresh supplies.

It is manifest that there must be some organization which shall keep order and discipline amongst the heterogeneous masses which compose these two streams; which shall form depôts in proper places; see to the supply of the sick and wounded; push on what is urgently wanted; economise and utilise the resources of the country whether friendly or hostile; direct those resources to proper places; maintain and repair the telegraphs, roads, railways, and bridges; garrison important points; protect and patrol the communications; check disorders; look after the dispatch of letters; and lastly, be such, that with but a short delay, can direct the whole of the vast traffic into another channel, should the movements of the army necessitate this being done.

This organization which the Germans term *etappen*, and which I have paraphrased as the "organization of the line of communications of an army," is that portion of the military art where study and forethought come most into play. It is that portion of the science of war, where the bright scintillations of genius, the sudden inspirations of the heaven-born leader, can do little or nothing. But it is on that account the more important; as careful, accurate, painstaking, study, and forethought applied to it, will go far to remove many of the indeterminate causes which mar the most brilliant schemes.

In war there can be nothing absolutely fixed, nothing rigorously systematic. But while this is true, it is equally true that the military machine is composed of many different parts that cannot be made to work for one end unless they all fit into a well arranged scheme. If all the details of such an organization be not clearly sketched out, well understood and thought over by every one, no amount of inspiration or feverish excitement will make things go straight when the machine is tried.

I quite concede that such an organization can only be tried in actual war, cannot be exercised in peace; but granting this, I believe that if the principles of such an organization be clearly laid down, and the functions of each person well understood by all concerned, the organization itself will quickly get into working order when wanted.

While then rigidity of form is inadmissible, yet it is desirable to have a standard or model, to reach which, every exertion should be made, even although such a standard may never be reached. It is very desirable in this matter, as in everything else, to establish some definite and clear principles of organization; details, however important, quickly arrange themselves if the framework or sketch be based on sound principles.

The first great principle which I believe modern experience has pointed out, is the division of the whole subject of supply into two great branches.

1st. That which works in rear of the army.

2nd. That which accompanies the army.

These two great branches should be perfectly distinct, their functions are different, and the class of men and conveyances to be used is in each case different.

The function of the first is to look after and forward stores massed in large depôts, and to push them up, as far as possible, after the army. Referring to the illustration of the bakeries in England, it is the duty of the organization in rear, to seek out, as it were, the food which each soldier would have eaten if he had remained at home, or in garrison, and to send it after him.

The function of the second is to bring up the food from the advanced magazines to the divisional depôts, at every opportunity, more especially during halts, and at the same time to seek to utilise the resources of the country by requisitions in the immediate neighbourhood of the marching troops.

It is manifest that the service in rear may be of a semi-civil character, the transport may be by rail, hired vehicles, or canals, while the service in the front must be military, and must be performed by bodies having a military organization. As an army advances into a hostile country, the requisitions in the immediate neighbourhood of the line of march will have, to a certain extent, exhausted the country; one object then of the semi-civil organization following in rear, will be to extend the area of requisitions, and to tap fresh supplies. In every case the furthest advanced point of the department working in rear should be as near as possible to the army in front, should follow it, and keep, if possible, within one or two marches of it, relieving the guards and detachments left in rear, completing any work that may have been done by the advance, strengthening bridges, repairing roads, laying telegraphs, and bringing up supplies. The transport working in front must, to prevent confusion, be under perfect military control, and must be able to bring up the supplies from the rear, that is to say, from the head or advanced portion of the rear-organization to the divisional depôts.

The food or supplies, however, have to be carried from those divisional depôts to the regiments themselves, and a fresh organization is requisite for this, which, being responsible for the supply of the units within the division, that is to say, the battalions, batteries, and regiments, must be a part or portion of these battalions, batteries, or regiments themselves.

Thus we are led to a division of transport into three portions, and I beg, gentlemen, to draw attention to this division, for in it I believe lies the key of success in this branch of the art of war, a division of transport into—

1st. General transport, embracing railway, canal, and road transport, working along the line of communication from the base to the most advanced magazine.

2nd. Departmental transport, which shall convey the supplies from the advanced magazine to the divisional depôts.

3rd. Regimental transport, which shall bring the supplies from the divisional depôt to the battalions, batteries, or regiments.

Accuracy of detail and economy of power are only to be found in an intelligent division of labour. By such a division of the transport, the smallest portion is that which, having to be always close to the troops on all roads, and even in the fields, must be highly organized

and well horsed. The Departmental transport, which need not move so rapidly, and generally moves at night, and always on roads, may carry heavier loads, or, what is the same thing, may use fewer horses, —while the transport working on the line of communication may, if it is not railway transport, be waggons hauled by relays of horses pressed from the inhabitants, and working a stage close to their own homes, thus avoiding the necessity of sending men and horses to the front, and further, relieving the magazines of the task of feeding horses and men so employed. The first description, General transport, must be under the Commandant of the line of communications, and under him alone; the second description, or Departmental transport, must be under the heads of departments—artillery, engineer, and commissariat; and the third, or Regimental transport, must be under the officers commanding regiments. When I say the transport is to be under these different directions, I mean not that the horses detached for any one service are invariably to be so employed, but I mean that these are to be their normal or general duties; it being always distinctly understood that any horse or any man in an army is liable for any duty the General commanding may choose to order. It would appear almost needless to say this, but it used to be an axiom in the French army that the "intendant" was responsible for the supply of food, the commanding officer of artillery for that of ammunition, and the commanding engineer for intrenching tools, each having his own train, while the general was responsible for handling the troops in action. This led to its natural results, the heads of each branch of the service rarely helped one another, and the general, shorn of half his attributes, lost his power. In an army-corps, division, brigade, or regiment, the commanding officer is alone, and can alone be responsible, for not only handling, but also for supplying the wants of his men. He may, and doubtless must have persons under him responsible to him for carrying out certain duties, but their responsibility is to him, and to no one else.

Many of the arrangements adopted in foreign armies, and which are too often supposed to be modern discoveries, will be found to have existed under different names and altered circumstances, in the Peninsular War. Wellington began with no organization, but originated as he went along, and his organization, adopted from experience, was in principle almost identical with what now holds in the German army. It is well worthy of study as given by Gurwood.

These were—1st. The regimental mule equipment (pack animals, to follow the troops through the difficult country they had to traverse in Spain). 2nd. The departmental transport, represented by the artillery train, the engineer train, and the commissariat train. The two first chiefly, though not altogether, composed of the corps of artillery drivers, and the latter composed chiefly of the Royal waggon train, while the general transport was represented by vast numbers of hired carriages and animals, comprising the ordnance and commissariat transport, and by boats on the Tagus and Douro, worked by seamen; the whole of the latter being under the general direction of the officer in charge of the communications. Allowing for the altered

circumstances, and the absence of railways and telegraphs, the system used in the Peninsula by Wellington was very similar to that now adopted in Europe, with, however, one important difference, to which your attention will be shortly directed.

Viewing then the question generally, we arrive at this point, that if an army is to be kept up to its fighting-strength in front, the communications must be worked by an organization separate and distinct from that in front. It is by no means meant that this organization should be distinct from and independent of the general commanding the army, far from it; the organization working on the line of communications should occupy the position, as regards the army, that an army-corps does, that is to say, the officer in command of the communication should hold to the general commanding, the position that an army-corps leader does. This is most distinctly laid down in foreign armies. If an army corps is working by itself it is really composed not of two, but of three divisions—one taking charge of the line of communication, and not being classed or counted as troops of the fighting line; similarly, if several army-corps forming an army are working together, there is another on the line of communication not counted or classed with the fighting troops.

Now this is the point where the modern foreign organization differs from that of Wellington, a difference undoubtedly caused by the small force at Wellington's disposal.

He was obliged to endeavour to look after his communications by means of detachments and convalescents—the results were constant abuses. We read continually in the pages of Napier of the cavalry regiments being dangerously weakened by detachments acting on the lines of communication really as military police. We read of constant abuses, arising from convalescents being detained in rear, and the fighting battalions in front being thereby weakened. Now in modern armies, the force told off for the communications is complete—it has its own battalions, its own commissariat, artillery, and engineer staffs, which hold to the heads of those departments with the army, the relations that similar officers do in divisions to the senior officers of those departments. Thus the troops in front are never weakened by detachments, and a division of 10,000 men on paper is really as nearly as possible of that strength on parade. The advantages of this as regards discipline are enormous—units such as regiments or battalions are not broken up to find garrison for this post or that important railway junction.

There is nothing more remarkable in examining from time to time the strength of the Prussian army in France than to see how closely the real strength of each corps corresponded with the regulation strength.

The advantages of doing away with detachments is too well known to require to be dwelt on here.

Indeed, if an army were to advance into a hostile country without such organization, it would soon reach the end of its tether, the fighting men in front would be gradually disseminated along the whole line of communication, and nothing would be left in front with which to meet the enemy.

In every army, there are and must be a very large number of semi-military bodies, that is to say, bodies possessing a certain amount of military organization, and yet whose function is not to fight but to work for those who do. These bodies are invaluable; but in front, their presence is absolutely hurtful; in rear, their duties are all important. Amongst these bodies, are the bakers, the butchers, the great mass of the telegraph corps, the railway corps, and a large proportion of the medical department. Further the protection and guard of the various posts in rear may be given to troops, inferior in marching power to those in front, and consequently we are again brought by another set of reasons to the fact that a separate and special organization is required for the line of communications.

Nothing more clearly demonstrates the value and importance of a careful preparation of these details, than the Franco-German war. Prussia conquered France, not so much from valour on the field of battle, as by the most painstaking care in every detail.

As the Prussian army advanced, it drew Prussian civil institutions after it; and the French statement, that France was invaded not by the Prussian army but by the whole Prussian nation, was literally true. As a general statement, it may be said that the collection of supplies at the base of operations is really the work not of the military leaders so much as of the civil administration of the State.

Acting on this idea, Coblentz, Mayence and Mannheim were the bases, or great depôts of the German armies at first; stores were accumulated at these places chiefly by the civil government, organized bodies in charge of the communications worked from those points to the army; gradually as the army advanced, these semi-military bodies followed; and were in their turn followed by a civil organization. First, a Governor of Alsace was appointed, next a Governor of Lorraine; and each functionary exercising the civil government of the State, allowed the semi-military bodies in charge of the communications to be pushed to the front, and finally the grand depôts originally on the Rhine, were pushed to the Moselle, the force in front thoroughly military, gradually shading off along its line of communication to the civil governors of the various provinces in the heart of Germany, where each corps had its home and peace station. The young unmarried men were in front, fighting and exposed, the older and married men in rear, each in proportion to his age and his power, doing his country's work.

To place highly trained military bodies to guard communications, to see after the police duty, to prepare relays of horses, or convoys of stores, is manifestly a waste of power. Looking to the two recent campaigns of 1866 and of 1870, it appears that in this organization the Prussians showed their superiority more than in anything else, the whole power of the State being devoted to one object. The Military Estimates in peace maintained the fighting men, and but a very feeble nucleus of these semi-military bodies; their peculiar institution of universal service enabling them to put their hands on as many men as they required at a moment's notice.

Thus when war broke out, every man in the country found his place

in the vast machine by which the fighting men in front were kept supplied. The French army had no such organization; and was so frittered away in detachments, and there was so much confusion, pillage, and waste in rear of their army, that, taught by experience, the new French military laws provide that men, who from their stature, or from some slight physical infirmity, are not placed in the ranks, are enrolled for these auxiliary branches of the army. In war, the more complex the military machine becomes, the more important becomes the moral power of armies; and I would venture to observe that armies only get more complex, because society itself gets more complex; because discoveries and inventions introduced into civil life are adopted into armies, because, in short, men are better educated, and the general standard of knowledge is everywhere higher, consequently moral force, as a lever that sways bodies of men of the size of modern armies, is more important now than when Napoleon said it was three times as important as physical force. Nothing tends to preserve moral force in armies so much as well ordered communications. It is not merely that regular supplies of food are brought up, that the men are regularly fed—although that goes for something—but the sick and wounded are got out of sight rapidly. Men's minds are not allowed to dwell on horrors, and above all, the reinforcements coming up from the rear, seeing regularity, order, and strict discipline in the rear of the army, are impressed with the sense of the power of the whole machine at work, and spread a healthy tone through the ranks they join.

It has often been said, and with great truth, that German military institutions have not been tried by defeat, that a concatenation of peculiar events has helped Germany in her great successes. This most undoubtedly is true; but if we examine her military institutions, we shall find that her leaders take precisely this view, and they have striven to produce a system that shall be available in the day of defeat as well as in that of victory; and nowhere is this anxious care more evident than in the organization of communications.

The service working in rear must therefore have a special and separate organization. In Germany (France and Austria have followed German arrangements to a great extent) there is an officer who commands the whole line of communications; his place is with the General commanding, or one march in rear of him, and under his orders he has six distinct branches working.

1st. The route service.
2nd. The railway service.
3rd. The field intendance or commissariat.
4th. The field medical depôt.
5th. The route telegraph.
6th. The field post office.

Each of these departments has its own head, and each is of a civil, or quasi civil character. Each has its purely military branch in front.

The Telegraph department is a good example of the way in which the civil shades off into the military.

It is divided into three distinct branches all under one head.

1st. The State or home telegraphs.

2nd. The route telegraphs along the line of communication, usually a light, overhead wire.

3rd. The field telegraph-detachments which communicate with the division and army corps. The latter being under the Generals commanding, the Director of military telegraphs deals with them through the generals.

As the army advances, the route telegraphs are rapidly laid, and the first, or State telegraph-department, follows and completes the work, connecting it with the general telegraph-network of the kingdom the Director General of State Telegraphs having as his assistant, or deputy, the Director of Military Telegraphs.

Thus there is no attempt to spread the field-telegraph-detachments out along the line of communications; being well horsed, and an entirely military body, their functions are to make a line each day to unite the divisions, a line that must be rolled up and re-made the next day. The route telegraphs are more permanent but less military in their character, the great object being to push the State telegraph as rapidly as possible in rear. Thus by a proper division of labour, the actual number of soldier-telegraphists is but small, and the money spent by the State on soldiers is thus kept as much as possible to pay for actual fighting men, those who work in rear, being, on account of their prospective service in this way, relieved of a certain portion of the service they otherwise would have to do in the ranks. Men so employed do not require periodical training as soldiers, they do not require more than a distinctive dress and a habit of respect for superiors. I do not now propose to attempt to describe these six divisions or branches of the communications of an army, but I cannot dismiss the second, or that of field railways, without saying a few words on this very important special branch of the subject.

The use of railways has introduced great changes into war, and it is believed that these changes may be summarized somewhat as follows:—

Viewed strategically, they have given an enormous power in concentrating masses of men and horses from the distant portions of a country on certain points; such concentrations in short as those effected by the Germans in 1870, on Coblentz, Mayence, and Mannheim. Viewed tactically, their use is restricted. Armies may be massed by these means at a secure distance from an enemy in a short time; but the moment that the distance between two contending armies becomes such that a powerful force must be ready to form in line of battle to meet an opposing army, the railway becomes for the purpose of moving troops of little value; but for the purpose of supplying troops, and removing sick and wounded, its value is at all times very great. Although universal compulsory service is more than sixty years old, I think we may fairly doubt the possibility of keeping the vast armies in the field that are thus placed in it, if railways did not exist. Suppose there had been no railways during the recent Franco-German war, I think it is exceedingly doubtful if Germany could have kept

400,000 or 500,000 men in the field. No amount of waggon transport would have fed them in France; and if such a force had attempted to advance, feeding on the country, it must have spread over so wide a front to seek subsistence, and its power to concentrate would have been diminished to such an extent, that its numerical value would have been greatly reduced.[1]

Railways must, therefore, be viewed in two distinct lights:—

1st. As means for concentrating armies from distant points, and for placing them on the theatre of war.

2nd. As means for supplying those armies while operating on the theatre of war.

This division is really that between railways actually in the zone of military operations and outside it.

In the former case the military element predominates; in the latter, the civil.

It is manifest that there must be a line of demarcation between these two. This the Germans term the transfer station. Take, for instance, the advance march of the Germans from the Rhine towards the Sarre. The Rhine was for some time the dividing line, Mayence, Manheim, and Coblentz being the transfer stations. East of these points the civil element prevailed; west, the military element was all powerful. The object being, as the army advanced, to push these transfer stations after it as quickly as possible, they were moved first to the Moselle, and subsequently to the Meuse, in each case the civil railways of the State extending their field of operations further to the west, and allowing the military organization to follow the army. The reason of this distinction is, that an army in the field depends for its supply on the productions of the country in rear of it, and it becomes essential not to dislocate the means of production, and to interfere with the trade and commerce of the country as little as possible. At the same time it is requisite that for a certain space in rear of the army it should have complete control over the railways; hence, a station must be selected where the separation takes place. The French made no such separation; and the consequence was that all kinds of stores, men and horses, were sent from all France to the army when actually in motion, there being no halting place out of the immediate zone of action, where the mass of supplies so sent could be arranged and forwarded as required; consequently the railways immediately in rear of the army were blocked and useless, and the waggons containing the things that really were wanted, never could be got at. I know of no more extraordinary description than that of the blocks of railway carriages in rear of the French Army at Le Mans, or in the town of Metz.

At the latter place nearly 7,000 carriages were blocked together in a solid mass; none of the people on the spot knew what the waggons contained—ammunition, food, clothes, arms, intrenching tools,

[1] The invasion of Russia by Napoleon is a case in point. Many writers have carefully examined this great episode, and all agree that no organization of carts or waggons could have fed so great a force so far from its base, but that a single line of railway would have done so with ease.

pontoons, and hospital arrangements, being mixed up in a confused mass—the power of the railway as a carrying agent being destroyed by its carriages being used as moving magazines. Had a transfer station been used, much of this confusion would have been prevented.

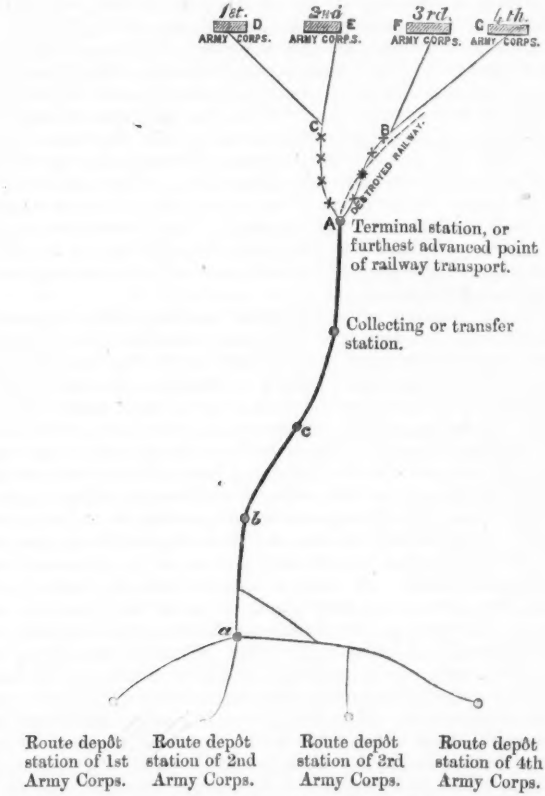
There is always a tendency to follow the lead of those who have been successful, and consequently since the successes of Prussia, there is a great tendency to Prussianize military matters. There is danger in this. There can be no doubt that, broadly speaking, the principles of war must be the same in every country, precisely as the principles which govern the administration of justice, the principles of music, painting, sculpture, &c., amongst civilised nations are identical. But each nation works out those principles in a different way; and any one who is a judge, will tell a French picture from a German, French music from German. So it must be with war—the principles which each nation has to deal with are identical. But in working those principles out, the peculiar idiosyncrasy of the nation must come into play. The outline of the picture in each case will be the same, but the colouring and detail will vary.

I am far from thinking or urging that we should adopt German customs in this country. But it is well to see what German customs are, and how the Germans have worked out the problem of utilizing their railways. When paying a visit to a German officer who filled an important position in a large fortress, I saw a table which looked like a kind of Bradshaw, and on asking what it was, I was told it was the annual mobilization table. "See here," my friend said, "if we will "have war, and to-morrow is the first day, I know that at four o'clock "a train containing so and so will arrive, at half-past five another, and "so on, for the nine days during which the operation of mobilization "takes place." And he told me that each year this table was altered, and every officer of certain grades had a copy of it. This table is really a very simple affair. An army is composed of men, horses, and stores; those men, horses, and stores, must in peace time be in certain known places. In war time they must be concentrated in other known places. Consequently it becomes a matter of simple calculation to determine where each of the scattered bodies or units can be best embarked in the railway waggons, and the time it will take to reach its point of destination. The table of mobilization is merely the result of a careful study of the subject. In Germany, a section of the Head Quarter Staff, aided by the Government Inspectors of Railways, prepares these tables and prepares a Bradshaw, which in war takes the place, while the army is concentrating, of the ordinary Bradshaw; certain of the ordinary trains ceasing to be civil and becoming military, and additional trains being added. On the completion of the mobilization, the railway section simply directs what trains are to run as military trains, and all the rest work as usual.

Further, as every unit has its fixed head-quarters, so each army-corps has its head quarters. And it is one of the functions of the railway section of the General Staff, aided by the Railway Inspectors, to select for each corps what is termed a "route depôt station;" to this

station everything belonging to the corps is sent, whether going to it, or coming from it.

These route depôt stations have each a commandant, they are selected after careful consideration, and if plenty of store and plat-



a, *b*, *c*, important points which should be the head-quarters of the railway working commission.

A, B, C, road transport by waggon to the route termini B and C, C D, C E, B F, B G, the lines on which the departmental transport works feeding the Army Corps from the route termini B and C.

form-accommodation does not exist, during peace, it is made; at this station the commandant is supreme.

Further, in peace-time a committee for each line, consisting of the traffic manager and a military officer, is appointed. The duties of this

committee are the following:—In case a country is plunged into war, there can be only a limited number of possible contingencies. These contingencies are determined carefully. The route-depôt station, and the places to which the troops and stores are to be moved, are also determined. The line committee determines where halts have to be made, where men and horses are to be fed and watered, and on single lines the passing places for trains. These points are all clearly laid down, and every one knows them. The commandant at the depôt station simply loads the men, horses, and stores he receives from the district of the corps; the line committee take charge of them and deliver them at the transfer station. It is manifest that the whole of these arrangements require nothing more than a little care and forethought, and a mixture of railway knowledge and military knowledge on the part of those who make them. There is no science required at all. Let us suppose for a moment that Scotland was a foreign country, with whom we were as likely to fight as we once were. And suppose we had 30,000 men stationed in Hampshire and Dorsetshire, 30,000 in the Midland counties, and 30,000 in Kent. The first step towards a mobilization of these forces for a Scottish war would be the selection of points of concentration for each body of troops; the determination of a route; depôt station; a detail of how the men, horses, and stores should get to that station; and the selection of a line of railway over which each corps was to move; the appointment of a line committee, consisting of military officers and the traffic managers of each line affected; and the determination of certain fixed trains to be used for through-traffic, and also certain places where men and horses might be fed, either breakfast, dinner, or tea, say six hours after starting. These conditions are clear and definite, and require only a little time to arrange. But where are these trains carrying all these men and stores to go to—where will you disembark your loads? Here we come to one of the most difficult problems to determine, and one on the correct determination of which, much depends. Are the Scotch likely to be more advanced in their preparation for war than we are? What is the political state of the country? What is the character of the leader, is the war popular, have they many railways to concentrate their troops with? All these questions enter into the determination of this point. It is manifest that if the point of disembarkation is chosen too far to the front, the troops and stores coming up in a long column by rail are liable to be greatly inconvenienced, perhaps not by the actual attack so much as by the threatened attack of the enemy.

If the point is too much to the rear, the full value of the railways will not be obtained, consequently the determination of this point is one of the greatest importance. Let us suppose York is the station selected, then that station becomes the transfer station or collecting station.

Behind that, all transport is worked as described under the regulations prepared carefully beforehand, as much as possible peace-traffic is maintained, and after the first concentration of troops takes place, certain military trains only are run. The points of departure and

the point of arrival once fixed, the concentration of troops becomes a simple matter.

Beyond York, no civil traffic of any kind would be allowed, and a military railway director, with very extended powers, would be appointed to work all the railway traffic north of York, acting, however, always under the orders of the officer in chief command of the communications. But let us carry our arrangements a little further, the Collecting Station, York, becomes then at once a great store.

The troops as they arrive are pushed through it at once, some by rail, some by road, towards definite points, where each of the three corps coming from Kent, Hampshire, and the Midland counties would be formed. The station at York would be placed under a commandant, who would issue orders somewhat similar to the following:—

"No trains containing military stores are to pass York."

"Trains with troops and ammunition may, unless specially ordered, pass."

"No train will go to the front that is not full."

"All provision trains will be unloaded, except in special cases, when definite instructions will be given."

"All trains coming from the army will run past York and not stop there."

Meantime, let us suppose that the Commissary-General of the army in front finds, or thinks he will find, difficulties in feeding the troops, on account of some flank movement that is going to be made against the Scotch army. He notifies the commandant of the line of communications of the quantity of provisions he is likely to require suddenly. These are loaded up, formed into trains, and pushed into sidings a few miles north of York, with a small guard which encamps beside them; a telegram from the front brings them on at once.

Similarly an action is expected, and hospital trains are formed, placed in sidings, with nurses, medical comforts, and a guard; a telegram brings them to the front at once, and the sick or wounded are carried far past York to the south.

North of York, the traffic would be entirely military, and worked under a military railway director, who would have under him a proper staff for that purpose, and who would arrange for all the traffic being worked in a regular way. But how far can such traffic be worked? How close to the army can the railway transport be brought up to the front? The answer to these questions depends on many things:—

1st. The line, is it destroyed or likely to be destroyed?

2nd. The nature of the stations available as terminal stations.

3rd. The prospects of a collision with the enemy.

4th. The nature of the roads and the horse-transport of the army corps.

5th. The situation of the army as regards the railway, and the front it was occupying.

But let us suppose a station selected, we will say Darlington, the enemy's army being somewhere in the neighbourhood of Newcastle.

Beyond Darlington, railway transport would, except in special cases, cease, and each army corps would have to send its departmental transport to Darlington for supplies. Darlington, the route-terminus, would be the point where the organization of the line of communications would cease; it would be the great point where distribution would commence.

Let us suppose, however, a little further, that the railway has been destroyed north of Darlington, and that the enemy, the Scotch, retreat; the army advances, and the distance from the route-terminus to the corps becomes too great for the departmental transport to work. The officer in command of the communications foreseeing this, and knowing the direction the army is marching in, fixes a fresh route-terminus and establishes a line of horse transport from the railway-terminus-Darlington, to the points he has selected; to these points the departmental-transport} now send for supplies, the transport of those supplies to the route-terminus, resting with the officer in charge of the communications, while a strong body of workmen would be put on the railway to repair it, and relay the rails, when the railway terminus would be again advanced, and so on. At the Collecting Station, York, supplies would be sought, not only in the south, but in the whole region round York, and each commissariat officer of the army-corps would seek by requisitions purchased, or other means, to relieve the strain on the communication as much as possible.

Such I believe to be the principles on which the Germans work railways, and undoubtedly so far as we can judge by the application of cause and effect, they are correct. I have tried not to burthen you with details, nor to enter into descriptions of how the complicated arrangements requisite for the organization of lines, may be best divided between the departments of the army. If the principles are sound, the details will quickly settle themselves. But this we may feel sure of, that though good men may make bad systems work, yet all systems should provide for being worked by mediocre or indifferent men; many details of the German regulations, however, do not appear to me to be so framed,—I say it with the greatest diffidence and submission. But the general principles which prevail the whole, are logical, clear, and definite, and I cannot better conclude than by quoting the opening words of their new regulations on this subject.

"The regular working of railways is of the first importance, not "only for warlike operations, but also as most materially affecting "national interests. The greatest care should be taken that they are "regularly worked; on the lines in rear of transfer-stations, the "ordinary traffic will not be interfered with for military purposes, "except when absolutely requisite. As a rule the ordinary public "trains will run, extra ones being added for military purposes. The "carrying powers of a railway are best developed by constant steady "traffic at regular intervals."

"Any interference with the regularity of the railway is fatal."

The CHAIRMAN: I trust I may be allowed, in the name of this meeting, to assure Colonel Home that the subject which he has treated to-night has been neither

tedious nor uninteresting, and I hope I may be allowed to thank him in the name of those who have listened to his lecture, for the instruction which he has managed to convey in so interesting a manner. Genius has been defined as a "vast capacity "for taking trouble;" and although I do not think that is by any means a correct definition, there can be no doubt that success in any enterprise, or any line of life, depends on a vast capacity for taking trouble; and I believe that the successes of the German armies in the two last wars were not so much owing to the manifestation of any great military genius on the part of the different generals, as to the vast capacity for taking trouble which was displayed in the bureaus of the military offices of the empire in anticipation of war, no branch of which is, probably, more important than that which Colonel Home has brought before us so ably to-night.

Colonel CHESNEY, R.E.: I should like to give one single illustration of the value of the system which Colonel Home has so ably explained, of which I happen to have gathered the particulars on the spot, when visiting it on behalf of our Government at the close of the war. It occurred at a part of the siege of Metz that there were some comparatively slight but still smart actions, partly by reserve troops hurried up soon after a great part of the army that had been round Metz, moved on towards Paris. Among these reserves were some from Wurtemburg. They came up not very long after the investment of Metz was complete, and almost immediately were brought into action; some of them had only just arrived. I learnt that they came into action, were wounded, and were conveyed by railway to the hospitals at Stuttgard, after a journey of less than twenty-four hours; so that it was affirmed that they were actually only thirty-six hours from the time they came before the French until the time they found themselves again in the heart of Germany, lying in their own town hospital. I suppose there can scarcely be a more striking instance of the value of perfect railway-management in maintaining unbroken the communications of an army with its base.

The CHAIRMAN: I am sure you will allow me to return your thanks to Colonel Home for his very valuable lecture.

Evening Meeting.

Monday, April 5th, 1875.

MAJOR-GENERAL R. C. H. TAYLOR, C.B., Inspector-General of Recruiting, in the Chair.

NAMES OF MEMBERS who joined the Institution between the 15th of March and the 5th of April, 1875.

LIFE.

Badgley, W. F., Capt. Ben. Staff Corps.
Bewicke, C. T., Lieut. R.N.
Boulderson, Samuel, Capt. 17th Lancers.
Fisher, E. D., Capt. 4th Hussars.

ANNUAL.

Gunter, H., Capt. 73rd Regiment.
McCoy, Washington, Lieut. South Devon. Militia.
Hoole, James, Lieut. 5th W. York Milt.
Lodge, J. W., Lieut. 5th W. York Militia.
Montagu, Andrew, Lieut. 5th W. York Militia.
Skrine, H. M., Major 1st Som. Rifle Volrs.
Underwood, P. C., Lieut. R.N.
De Schmid, H. W. F., Capt. South Devon Militia.

ON TRAINING BOYS FOR SOLDIERS.

By JOHN MACGREGOR, Esq., M.A., Chairman of the Industrial Schools Committee, of the London School Board.

THE following letter appeared lately in the "Times:"—

"Recruits for the Army.

"To the Editor of the 'Times.'

"Sir,

"Why not train some boys for soldiers while other boys are trained for sea?

"Of the 8,000 boys in certified industrial schools, who must leave at 16 years of age, some hundreds at least would become soldiers, but they may not enlist until they are 18 years old, except as band boys. Many of these are Irish, who prefer the camp to the forecastle, while their patrons object to send them as band boys for reasons I cannot specify here.

"Bridge the two years of interval by opening a 'cadet school' at some military centre. The industrial work of lads properly selected would pay for a great part of their keep. Their *physique* and educational, moral, and military training would be far above that of the average recruit. Of the 2,000 other boys in refuges, and hundreds of outsiders in private life, many would be attracted by a 'Boy Brigade,' and often friends would pay.

"At present, we close the door to the Army until an age when all these youngsters have diverged to uncongenial, overstocked trades. Then, two years later, we purchase their service for the Army at a

high price, and then wonder that they desert and fill military prisons, or retire to fall back upon handicrafts which they know enough to trust to and not enough to live by." * *—*Dec.* 1874.—J. M.

We are met to consider the following question:—"Why not train some boys for soldiers while other boys are trained for sea?" and I have been invited to state why we *should* train boys for soldiers, and how it may be done so as to be good for the Army, the boys, and the nation.

Now the value of any person's opinion and suggestions upon this subject will a good deal depend upon his knowledge of the matter in these three parts:—

(1.) The number and kind of recruits required.

(2.) The number and kind of boys that can be trained.

(3.) The comparative cost, and value of trained lads.

An observant military Officer can know one part, and a practical educationist can understand the two other parts of the subject; but as no one man can devote his chief attention to both these lines of observation, we may regard with indulgence the present endeavour to look on all sides of the question by one who is deeply interested in the Army, and who has had for many years exceptional opportunities for knowing the wants and ways of boys, and how to deal with them.

Last year, to sustain an Army of 200,000 men (half of them at home), we obtained 20,000 recruits, but under the operation of the short service system double this number of recruits will soon be required every year.

As to the kind of recruits obtained, it will be admitted that in *physique* and character too many of them are not good, and too few are suitable for promotion as non-commissioned Officers.

On this subject we may hear the recent opinion of a high responsible authority. In his speech, not a month ago, Mr. Gathorne Hardy said in the House of Commons:—

"It has been generally supposed, and indeed there is no doubt, that "there is a general disinclination on the part of a better class to enter "the ranks of the Army.

"I should be extremely glad if recruits would come forward of a "higher class than the majority of those I saw; but when I am asked "to take none but men of 20, I say, is it possible to procure men of "20 while labour in this country is in its present state? A labouring "man of 20 has settled down to a particular work."—*Times, March* 9.

And on this subject, Major Campbell, Governor of the Military Prison at Cork, says:—"I remark that nearly all the tradesmen who "have been admitted during the year have been convicted of desertion; "a good tradesman finds it difficult to resist deserting when wages are "so high."—*Report on Military Prisons.*

Such is the present state of the demand for recruits, and the supply; and it is not caused by want of public interest in the Army, or lack of strenuous efforts in the Recruiting Department, or neglect of important improvements in the soldier's life, as to his barracks, food, and clothing, education, recreation, and pay, his library, savings bank, canteen, and gymnasium.

It will be acknowledged, then, that we want many more recruits and those of a better class; that we must enlarge enlistment and decrease desertion and wasteful discharge.

Three modes of supplying these wants have been suggested:—

1. *Compulsory service* or a general conscription like that made in France a few weeks ago.

However desirable and sufficient this might be, it is not at present probable; and, at any rate, it is beyond the consideration of this paper.

2. Another suggestion for removing our difficulties is to improve and extend the mode of recruiting, and doubtless much can be done by this.

War is a business, and it is the only great business where we go into the market so late to get what we want, and where we expect people to come and help by thousands without being invited.

We treat the matter almost as if crowds of suitable men were pressing for admission to the ranks of our Army; whereas, practically, anyone who can scrape through the very moderate physical examination, be he a dunce, or a rogue, or a run-a-way, expects to be thankfully accepted, and is seldom disappointed.

Of the 40,000 clergy and ministers, the 100,000 teachers of the young, the 150,000 volunteers and thousands of other civilians whose words have weight with the very youths we want, how many are ever pointedly asked to help in recruiting? How little we use for this purpose the pulpit, the platform, or the press, or the other popular channels for information!

The day is happily gone by for getting soldiers with a glass of gin; but, while this bad way is abandoned, many good ways are untried. The recruiting-sergeant is well enough for the lad who is three-fourths decided to join; yet after all, it is the civilian friends of the Army who can best explain its advantages to their own companions, and not the slightest encouragement, that I have ever heard of, is given for aid of this sort.

Sergeants in gay colours may preach up the Army to get recruits, but the preachers who tell most of all on those outside are the men who *have been* soldiers, and who have left the Army and are now civilians again.

If these men are contented in their retirement, their lives, their looks, and their words will persuade others to enlist; but if they are discontented or in disgrace, they will, and they do, deter thousands.

Every man of the 6,000 who deserted, and of the 2,000 discharged in disgrace in the year, feels bound to run down the military system; for, of course, he thinks, or at any rate he says, that it is the Army and not he that is in the wrong.

Every deserter not punished (and that is two out of three), shows that desertion is easy, and every deserter punished, costs much by his loss and his punishment, but more by deterring new comers.

3. A third mode suggested for securing good recruits is to increase the inducements by pay. Putting it shortly, men can be had to do anything for pay, and good pay will get good recruits.

Thoroughly believing this, and that the soldier's pay and pension should be increased and must be increased, still there is the question "when, where, and how, and for whom, ought to be the outlay so as to secure the best return?"

Shall we spend more in soliciting, persuading, not to say inveigling the tired, restless lad whose character has gone and whose work has failed, whose relations are disgusted, and who is himself demoralised? Shall we spend more in feeding him up and drilling and doctoring him, and catching him as a deserter, and punishing him as a convict, and then turn him out to justify his misdeeds, and to decry the Army with all his might for years?

Or shall we not rather try what may be secured by paying something at an earlier stage of this youth's life, by selecting him as a willing boy, educated morally, mentally, and physically, by spending our money in preparing, and not in purchasing and punishing him?

Let us buy the young sapling and not the twisted tree.

Of course there is nothing new in the proposal to train boys for soldiers.[1] It has been often urged and discussed, but it ought to be considered again, and all other plans, too, must be considered anew; because, in one way or another, our recruits must be doubled in number and improved in kind.

If lads are to be trained for soldiers, there are six important sources of supply which are almost unused:—

1. Reformatories.
2. Industrial schools.
3. Workhouse union schools.
4. Voluntary refuges for boys.
5. Elementary schools.
6. Other boys in ordinary life.

Let us see how many inmates in these are available for making soldiers after a period of training; how many at present do enlist from these sources; and how we may obtain from them a large and regular supply.

1. In January last year there were, under the detention of Reformatory schools in England and Scotland, 5,500 boys, of whom half had been admitted at the average age of 15 years, and most of them on a first conviction, so that after two years as inmates,[2] and a year's training outside, 500 could be soldiers so far as age is concerned.

2. At the same time there were 9,000 boys in Industrial schools, of whom 2,000 were of the average age of 15 years; and of these 500 could be soldiers after a year's residence and two years of training.

3. There are now in the Poor Law Union Schools of England 18,000 boys, of whom 6,000 may be estimated as available for military life, and 500 could become soldiers after three years training.

Besides these, there are 50,000 boys relieved by the poor-rates, of whom at least 500 could become soldiers after three years training.

[1] Recent pamphlets on this subject have been published by Colonel Alcock, Mr. J. O. Chadwick, Mr. R. J. Hamilton, and others.

[2] The term of detention may be lessened on recommendation in any case for good conduct, and fitness, and readiness to enlist or enter any respectable career.

4. There are, in London alone, Voluntary Refuges for boys, containing 2,000, of various ages, who are maintained and educated by voluntary subscriptions. I believe that 500 of the boys from such institutions in Britain could become soldiers after a year's residence and two years training.

5. There are many thousand boys in elementary day schools, helped by Government aid and by public rates. They are drilled and instructed, but no special means are taken to show them that the Army is a noble profession. I believe that, at least, 1,500 of these could be soldiers after two years training.

6. Outside all these, there are the countless boys in ordinary life, of whom thousands could be induced to enlist, and at least 1,000 could become soldiers after two years training.

From these six sources, then, I estimate that certainly 5,000 lads could be obtained every year, fit and willing to be trained and to enlist.

Now, here we must inquire—

(1.) How many of these eligible lads do enlist at present?

(2.) What are the reasons why more of them do not enlist?

(1.) In reply to the first question, as to how many do enlist, we find that—

From the Reformatories, in the last twenty years, 16,000 lads were discharged, but only 419 left for enlistment, or 1 in 40.

From the Industrial schools, in the last ten years, 17,000 boys were discharged, of whom 176 left for enlistment, or about 1 in 100.

From the Workhouse schools as a whole, I have no records on this point, but any one who saw 4,000 Workhouse boys march past the Prince of Wales, in 1873, would wish that every one of them could be trained to defend England.

It appeared very desirable to obtain recent and reliable information upon the two questions mentioned above, with respect at least to the three classes of institutions which are supported by public money, and I therefore addressed a circular to about 100 Reformatories, Industrial schools, and large Union schools. In reply to this, I have received authoritative detailed information from 24 Reformatories, 44 Industrial schools, and 9 large Union schools.

Last month there were, in these 77 schools, 10,088 boys, of whom 7,567 were regularly drilled. The total number of at least 15 years old, who had left the schools in the last 5 years, was 7,110, and of these only 641 were known to have become band boys and 332 to have enlisted as soldiers.

As a whole, then, one out of every seven discharged from these selected and best schools went into the Army, but not one in twenty as soldiers.

Analysing the details we find that, even of this small number who go to the Army, a large proportion come from a few schools, showing clearly that, where certain plots of the field are worked, as the whole ought to be, the yield is considerable.

Thus, of the 641 who became band boys in 5 years (out of 7,000 who left), 280 were from two Union schools with 800 children inmates, and 221 were from Feltham Industrial School, with 680 inmates, so

that 500 band boys came from three schools, holding 1,500 inmates, while from all the other schools, holding 8,500 inmates, only 140 band boys came in five years.

Similarly as to soldiers. Of the 332 who enlisted in five years, two-thirds came from Reformatories[1] with 3,000 inmates, or 1 in 75; but from the Industrial schools, holding 4,300, only 100 enlisted, or 1 in 200 inmates; while, from the Workhouse schools, with 2,500 inmates, only 5 soldiers came, or 1 soldier a-year.

It is evident then, that, while the supply of soldiers from some Reformatories, Industrial schools, and Workhouses shows that these sources are available, the total number obtained from them is lamentably, if not ludicrously small, and let us, therefore, hear what are the reasons assigned by the managers for this.

(2.) In reply to my second question, "What are the reasons why more do not enlist?" the following answers are given by the Superintendents or other responsible authorities:—

(*a.*) In four institutions the managers objected to send the lads into the Army.

(*b.*) In five, they say no desire exists for military life.

(*c.*) In nine, the height and size of lads required caused the difficulty.

(*d.*) Ten say that the parents of their inmates object to the Army as a career.

(*e.*) In twelve institutions their lads could not enlist, because boys, however good, are refused if they come strait from a Reformatory, although many of these same lads are readily enlisted after a week or two spent in the wretched life outside.

(*f.*) The managers of 21 institutions say that they have lads able and willing to enlist, but they are below the age required. One says that his institution has sent 4,000 lads into life, and 1,000 within the last five years, and that many of them very much desire to become soldiers, but they are refused.

In addition to this testimony, I may add, from my own personal experience in working the *Central Shoeblack Society*[2] of London, during twenty-four years, and which has sent 4,000 lads into life, that many clever, sensible, well-built lads wished to enlist, but were too young to be received; one of these was ready to spend £60, of his own savings, to fit him for a soldier, but there was no school to go to for the two years required.

Now, all these objections are removable, by the plan to be proposed, except the obstacle from the regulation carried out, in some places, by the military authorities, not to enlist a lad from a Reformatory, be he ever so good.

But what comes of this foolish rule? One Reformatory says, "many "would go into the Army, and the greater part would be excellent "soldiers." Another says that, even with this restriction, 10 out of 81 boys they got out did enlist. Another tells how their boys travelled

[1] 67 of these came from three Reformatories in Ireland, 23 from one in Surrey, 12 from Leeds, and 10 each from Hants and York.

[2] This is the oldest of six Shoeblack Societies in London, which, with 400 boys, earn £12,000 per annum.

60 miles to be enlisted, but were refused, and yet got in at last elsewhere, and are doing well, as soldiers.

In fact, this absurd rule keeps out only the lads who are honest, and who truthfully tell where they came from; but it lets in the worst Reformatory lads, who conceal their past life, or who lapse into idleness and crime, and are welcomed then as soldiers. At any rate, it ends in this, that more Reformatory lads do enlist than boys from industrial schools, in the proportion of three to one.

A restriction which is thus unreasonable and nugatory cannot, of course, be maintained.

As to the supply to be expected from lads in Voluntary Refuges, and from those outside, it is to be remembered that relations, friends, patrons, and benevolent persons unconnected with the particular cases, do at present pay to support and train lads in ships, refuges, and homes, £12, £15, and even £20 a-year; and, after my personal knowledge of the cases of 6,000 poor boys disposed of in various ways, I know that £10 per annum for two years would be easily obtained for such paid cases to make the boys into soldiers.

On this subject a Recruiting Officer states that in his District he could at once obtain 500 unobjectionable boys, but does not know where to get five unobjectionable men.

Having briefly considered the want of recruits, the sources and modes of supply at present used, and the additional source from whence more recruits could be obtained by proper means, I will now sketch the plan for training lads who are willing, but are not yet fit, to be soldiers.

The experiment can be tried on a small scale, so that, at the worst, it would be a small failure, but it might be a great success. It would not at all interfere with the discipline or plans of the Army, but would stand or fall alone. It would not be a substitute for other modes of recruiting, but a clear addition to them. Suppose, however, that it becomes a great success and produces 5,000 good recruits yearly; some may say that is only one-eighth of the 40,000 men we shall need. True, but do we not open up a new and vast source of larger supply? Meanwhile even little helps to a great need must not be despised.

Establish, then, as an experiment, an institution to maintain, instruct, and train for the Army, lads from 15 to 17 years old when they enter, selected as fit and willing to become soldiers; none should leave until 18 years old.

The name of the institution should not include the word "school;" for lads at that age are tired of that word, but the title might be—

The Youths Brigade or Battalion.

The Boys Regiment or Company.

The Recruit Corps or Depôt.

The Barrack should be near one of the Brigade Depôts.

The corps should consist of 500 lads from Reformatories, Industrial schools, Union schools, Voluntary institutions, and outsiders, say 100 from each. All of these should be enlisted before joining.

The "Time Table" might prescribe—

Two or three hours for education, religious and secular.
Two or three hours for drill and gymnastics.
Four hours industrial work, indoors and out.
Six hours meals, and recreation.
Eight hours sleep.

The industrial work should comprise all the clothing, cooking, and baking for the corps; and the artisan work of saddlery, harness, and leather accoutrements for the Army; also land culture, to accustom to spade and pick, and other work in special trades. The depôt might well become a staff-store department of all kinds of work.

Pocket-money should be given in proportion to industrial earnings, and prizes for shooting and progress and good conduct. Music and drawing and the other accessories of education should be supplied, and full dress and undress uniform should be worn.

Of course a high moral tone should be infused into every part of the institution; and, as the mainspring of this, a frank and hearty religious spirit. Not to speak of ancient Jewish warriors and Christian soldiers now-a-days in England and America, let us remember that even in heathen lands the hardiest Army that conquered the world had, among its Captains, the "devout man" Cornelius, who "feared God," and another Centurion who acknowledged the "Righteous" one upon the Cross; and another who had greater faith than was found in Israel, and yet another Roman Captain who helped because he was "willing to save" Paul "the prisoner."

A general sketch of what has been now described was sent to the various institutions already mentioned, and the opinions of their managers were invited..

In reply, some few objected to minor details, and four out of the eighty doubted whether it was feasible and desirable, while twenty gave no definite opinion. Approval of the plan came from more than half of the institutions, including the largest and the best; and some expressed their encouragement in earnest terms as follows:—

"Fully one half of our boys (350) would become soldiers if they found it possible to enlist." The proposed Youths Brigade, others say, would be "a great blessing," "a capital thing," "a most admirable "bridge." One school in Jersey highly approves "for the sake of the "boys, the Army, and the nation." Another says it is "an excellent "plan for supplying a long-felt want;" another, that "more boys are "asked for by Commanding Officers than he can supply;" and another that "all his eldest boys would make capital soldiers, and those growing "up the same." While a few of the managers doubt whether any voluntary cases would be sent and paid for at £10 per annum, others declare that such cases would be numerous; and my own opinion is, that their number would be sure to warrant that part of the experiment.

We may therefore count upon hearty co-operation from a large number of institutions, but even without any such encouragement, most people will allow that the experiment should be tried if the expense of obtaining a good recruit by means of it compares favourably with the expense of securing an ordinary recruit.

Now, it is obvious that the selected recruit, educated, drilled, dis-

ciplined, and trained, cannot, with fairness, be compared with the ordinary raw recruit as he joins his regiment; for this lad will require at least six months of barrack life before he is equal to the trained man, even for ordinary military purposes.

Let us, therefore, compare the expense of a recruit of each kind up to the time when they are more equal in usefulness, that is to say, the total money expended on the trained recruit as against the total expended on the ordinary recruit of six months' service.

Now the form in which military accounts are published makes it difficult to ascertain the cost of an ordinary recruit, but perhaps the following will suffice:—

There is the expense of the recruiting staff, "levy money, &c.," £35,000 for 20,000 recruits, or £1 15*s.* for each; then there is his pay for six months, at 1*s.* a-day, that will be £9 2*s.*; and then his barrack, keep, education, and drill, say at 3*s.* per week, would be £3 18*s.*, or a total of £14 15*s.* for the expense of the recruit at the end of six months' service.

Logically we ought, perhaps, to add at least a large share of the money absolutely lost by the 300 desertions of soldiers under six months' service, the money lost by the 1,000 discharges for bad characters, and by the loss of 2,500 deserters at all stages in the half year; also the money expended in punishing the 900 deserters caught in that time, and imprisoned on the average for four months, at £30 per annum each.[1] But it is better to forego the addition of these items in actual money, provided we clearly understamd that a selected, willing, trained recruit will certainly cost much less in these ways than the other man.

In estimating the cost of our trained recruit, we presume that he enters the depôt at the average age of 16, and remains two years before joining a regiment. After a year and a half of training he will be 17½ years old, and, if otherwise suitable, he might have been allowed to join a regiment under the Army regulation as a "very "eligible lad not under 17 years of age," but, nevertheless, let him be kept on still another half-year, to fill up his frame, to complete his education, and to fill up his time to 18 years.

For such a lad, the general style and scale of premises, maintenance, and management, need not be more expensive than those in the five larger of the forty industrial schools with which my official duties make me particularly acquainted; and, giving a margin even beyond this expense, I estimate that £25 a-year will pay for all that is required.

Now the lad we have in hand has been selected for good character and *physique*, and industrial capability. He has passed the time when beginners spoil tools and waste material, so that I would estimate the clear profits from (*a*) his industrial work at 5*s.* per week, or £13 per annum. Next we must recollect that each of the 300 lads at our depôt from Reformatories, Industrial schools, and Union schools, will have £3 paid for his outfit by the usual grants from the Treasury and rates,

[1] Lieutenant-General Sir Lintorn Simmons said (April 9, 1875):—
"The men who disappeared in 1873 cost the country in actual money £596,563, "exclusive of depôt charges."

which for (*b*) each of the 500 makes the sum of 18*s.* per annum. (*c*) Again, the sum of £10 paid yearly for each of 100 lads, as described, will give for each of the 500 the sum of £2 per annum.

Therefore, deducting from the two years' expense of £50, (*a*) the sum of £26 for profits, (*b*) £1 16*s.* for outfits, and (*c*) £4 for payments, we find that our trained recruit costs £7 9*s.* more than the ordinary recruit at the end of six months; and if we add £2 11*s.* for pocket money (at 6*d.* a week), the total extra expense is £10.

I am fully aware that, although our trained soldier may be well asserted to be worth at least £10 more than the average recruit after six months service, even this additional outlay on the trained man must be fully justified on other grounds, else the military authorities would not dare to ask for that sum, nor the Secretary for War venture to propose the vote.

But we have in this case, happily, the full justification of precedent; for in other departments of State, when good men are wanted, much larger sums are given for trained lads.

For a long time the Royal Navy tried to get able seamen from the sailors market, but they are wise enough now to train up boys, and this has been found so successful, that 6,000 boys are training for sailors. They are entered at from 15½ to 16 years of age, and are usually transferred as first-class boys to a sea-going ship, and at 18 years old they rate as able seamen. The cost of each boy's training for the Navy is £60, which is willingly paid by the nation because the boys thus trained become splendid seamen.

For a long time, also, the Merchant Navy (after ceasing to train boys) tried to get men for sailors, but now they too are wise enough to ask for trained boys; and in the *Merchant Shipping Bill*, to be discussed in a few days, it is proposed to give for each suitable boy trained for two years, who becomes a seaman, £30; and this, be it remembered, from a special Shipowners' fund, and not from the public purse; while the Admiralty have promised to grant the use of Training-ships, which are, in fact, premises without rent.

And now, in conclusion, the question asked by me in the "Times" newspaper remains to be answered.

"Why not train some boys for soldiers while other boys are trained for sea?"

When £60 is given to train a boy for the Navy, and £30 is given to train a boy for a merchant seaman, will it be too much to give £10, or even £20, to train a lad for the Army?

If, indeed, this outlay shall, after fair trial, be proved to be too much for the positive benefit obtained, then my project falls to the ground; and while I shall thank those friends who have considered it, I will humbly apologise to those who have lost their time in the matter. But if, by the means proposed, even 1,000 good soldiers can be added to the Queen's Army, it will be gratifying to us all, and not least to one whose boyhood was passed in barracks, and whose venerable father (having himself received his commission when yet a boy) left in the regiment which he last commanded a little lad, the only person still in the same corps, the present Lieutenant-Colonel of the 93rd Highlanders.

Mr. CARLTON TUFNELL: I have taken considerable interest in the subject that has been brought before us, having been for several years the official inspector of the greater proportion of the schools mentioned by Mr. Macgregor, in his lecture. I think that he has pointed out the proper mode of meeting the difficulty, now very strongly felt in this country, of procuring recruits for the Army. The schools of the Local Government Board are filled by sixty per cent. of orphans, and it has been absolutely necessary to bring them up to some trade. Many years ago, I was obliged to pay particular attention to the sort of trade we could bring them up to, and how we could so train them as to enable them to obtain an honest independence in after life. I soon found that there was a great demand for boys in the Army, of a certain description, and the War Office told me, if I would only take care that the boys were properly instructed in music, a great number could be taken into the Army. I was also told that, if I put these boys to drumming, they would take a number of them as drummers, for it was only by early training that they could acquire the elasticity of wrist requisite for that occupation. I was told afterwards that there was a great want of tailors in the Army, and they said to me at the War Office,—"Cannot you put the boys to tailoring? for, if they can "do that work, we shall be happy to take a great many of them into the Army." Well, all this was done. I persuaded the Government to appoint band-masters and drill-masters to these schools—tailors were always employed before—in short, I wished to make the schools as military as I possibly could. The effect of this was seen in the drill reviews that have taken place, for three successive years, in this country. The first took place in the year 1869, at the Crystal Palace, when Sir John Burgoyne wrote a letter, afterwards published in the newspapers, giving the very highest credit to the schools for the way in which the boys did their drill. There have been two other reviews since, in Hyde Park and in the Horticultural Gardens, and I believe every military man who saw what was done by the schools must have regretted that the children were destined for any other profession than that of the Army. Mr. Macgregor has mentioned the number that have gone from these schools, and, according to the tables I have, I think he has somewhat underrated that number. We find, from the sixteen Metropolitan Poor Law Schools alone, in 1870, there went 240 musicians to the Army, 119 to the Navy, and 7 as tailors. In the next year, 236 went into the Army. Those numbers do not quite coincide with the numbers given by Mr. Macgregor, who, I believe, has not included all the London Poor Law Schools in his calculation. I find, from the reports of the Inspector-General on recruiting, that the boys who have gone from those schools into the Army have given the highest satisfaction to their Commanding Officers. They have generally gone as musicians, but being so well instructed in intellectual matters—in reading, writing, and arithmetic—many of them have been lost as musicians, and have become non-commissioned officers. Of course, we have experienced difficulties in carrying out this matter. These boys are mostly London boys, and are extremely well fitted for the service in most particulars, except one; they are very clever, apt, ready to learn, very good humoured and courageous, and, if they are musicians, they generally play their instruments exceedingly well; but they are all deficient in stature, and that is the difficulty we cannot get over with London boys and boys from large towns. If we could get country boys, we should have much less difficulty in supplying the wants of the Army, for their physique would be very much superior. London boys, unfortunately, are so stunted in growth that they very often give dissatisfaction when first enlisted in a regiment, but after a time, however, when the Officers find how intelligent and obedient they are, and that they know their drill, they are perfectly well satisfied with them, and I thing they like them better than any other recruits, because their intellectual education is extremely good, it being compulsory in the schools where they have been trained, and hence, besides the advantage of knowing their drill, they have been far better taught than in ordinary village schools. Then, there is another difficulty I have met with. Everyone knows that, amongst many of the lower classes in this country, there is a sort of objection to going into the Army, according to a saying which is general amongst them, that "You are going to be shot at for a shilling a day," and it is astonishing what damage that single sentence does. The consequence is, when these boys have relations or parents, they try all in their power to

prevent them going into the Army. Now, the War Office have a very good rule, on the whole—that they will never allow any boy to enter the Army without the consent of his parents. As respects the upper, the middle, and lower classes, it is a very proper rule, and ought to be observed; but, with respect to these lowest classes of all in the Reformatories, or these Poor Law Schools, the rule seems to me cruel and unwise. It often happens that a pauper parent, or even a convict parent, prevents a boy from entering the Army who is well fitted for it. I have a case before me now of a boy who played the cornet perfectly well, and wanted to go into the Army; his father, who was a convict, would not allow him to go, and the Army would not receive him without the convict's consent. That is a rule, I think, that ought not to be followed strictly. A case occurred, only within this last week, where a boy was sent out of one of the largest schools, well instructed as a tailor; he went to the 46th Regiment, and was going on extremely well, being very happy and very comfortable. He had been deserted, and had not seen a parent, friend, or relation for years, but, as it often happens in such cases, when the boy was sent into the world and was gaining an honest living, a woman, a pauper receiving relief, came forward and said she was his mother, and angrily declared to the guardians, "I insist that my boy shall not remain in the Army." The consequence was, the guardians sent word to the Horse Guards, and they, unwisely, I think, sent him back. The boy was a fine looking boy, as well fitted as any boy could be to make a good soldier. He was a very good tailor, and was working with the regiment, giving perfect satisfaction. He came before the board of guardians, in his uniform, and said he did not wish to leave, but his mother insisted that he should go. The boy was perfectly broken-hearted, and his mother being utterly unable to assist him, he is now selling matches in the streets. I think the rule of requiring parental consent should not be observed in such cases. Sometime ago I made an application to the War Office to beg them not to follow this rule in the case of children from these schools. The case was laid before the solicitor, and what he said to me was this—that, if the children had made their engagement with the Crown under the sanction of the Poor Law Authorities or industrial schools, he would neither give them up nor compensate the parents. I think after that, it should not have been done. I think the Office has forgotten this, and the result is, boys are frequently sent back who are perfectly fitted for the Army, because their foolish parents insist that they should not be soldiers. That is a rule which stands very much in the way of the enlistment of this class of boys. If it were not for this rule there would be a great many more boys ready and willing to enlist, and I think if they are willing to enlist, their parents should not be allowed to have any voice in the matter, when the boy has been brought up at the public expense. I do not know whether it would be absolutely necessary to carry out Mr. Macgregor's idea, that we should first found a school for the purpose of training boys for the Army. It has often struck me that there is a school in existence which ought to be appropriated to that purpose—I mean the Duke of York's School—but at present it is a mere charity school. The original intention was, I have no doubt, to benefit the Army, and no fault can be found with its present management as a charity school, but it would be of great use to the Army if it could be transformed into a training school for young recruits, in the way suggested by Mr. Macgregor. They now take children into it as low as seven; there is no examination to see if they are fitted for the Army, and no compulsion to make them go into the Army, the consequence is, the school is of very little use in supplying recruits for the Army. Perhaps that school could be appropriated to the purpose Mr. Macgregor has mentioned. The boys should not be received under a certain age, and then it could be turned into a sort of cadet school for the whole Army. Mr. Macgregor mentioned the age of sixteen, but there is a difficulty in putting it to so late a period of life. Boys in that rank of life get into their permanent occupations much earlier than they used to do, and I would sooner see them received at fifteen instead of sixteen.

Mr. MACGREGOR: I said from fifteen to seventeen, and that the average was sixteen.

Mr. TUFNELL: These are in reformatory schools, and, in the Poor Law Schools, and the boys cost at least £25 a-year to keep; therefore, the persons who maintain the

schools are extremely desirous of getting rid of them as soon as possible. If you do not take them at rather an early age, they will get them out to other occupations, and you will never see them at all.

Lieutenant-General Sir DAVID RUSSELL: If the requisitions of the foolish parents were all to be attended to, it would be necessary to keep an extra staff of clerks to answer the enquiries made.

Major-General Sir CHARLES DAUBENEY: I take it, Sir, that after the boys are enlisted, the parents have nothing further to do in the matter. An enlisted boy is like an enlisted soldier, and unless he himself agrees, or is over-persuaded by his parents, he cannot be discharged from the service, and, even then, there must be a heavy compensation paid by some one before he can get his discharge. I think that the question should be decided by the boys themselves being appealed to, and if they decide to remain in the service, and have been properly enlisted, I do not think that what the parents may have to say upon the subject should be taken into consideration. I quite agree with what has been stated about reformatory and industrial schools. I have been myself for some time, as a magistrate, connected with industrial schools, and have had a good deal to do with them. Looking at them from a professional point of view,—for I must say I went to them with the eyes of an Officer as well as those of a magistrate,—I was very glad to see the educational progress made by the boys, and I also saw a great number of boys of excellent *physique*—boys who might have turned out as good soldiers as any that I ever saw in my life. They were trained and educated for general purposes, as it might be, but at the end of their time they had the option, to a certain degree, of deciding where they would go to. I have heard it said, in fact, I am able to say it as a fact, that some Commanding Officers object to take boys from these industrial schools, because they are afraid that they will contaminate those with whom they are associated. Having had a good deal of experience, I must say I think this a very groundless objection, for where do we get our every-day recruits from? We do not know, when we enlist a recruit to-day, what his antecedents were yesterday; he might have been anything yesterday—the vilest man in the kingdom—and yet, if he is physically fit for the service, he must be taken. Well, you have the guarantee, at all events, of these schools, that the boys who are in them have not been committed for any serious crime. They have been under tuition for three or four years, receiving reformatory training, and, if that is worth anything, it must, as a matter of course, have produced its effect in making them better subjects, according to the length of the training and the mental capabilities of each boy. At all events, you do know something of that boy for three or four years previously, and you very often know nothing of the antecedents of the recruit that you enlisted yesterday. Therefore, to say that because a boy has been in an industrial school or a reformatory, or anything of that sort, he is not eligible to be put into the Army is, I think, a very strained objection. Besides, it is well known that the authorities of those schools take very good care not to send you an unreformed boy, because such boys are all put into a separate class, by themselves. They would only send you boys who would give a good promise of making good subjects as soldiers hereafter. I think Mr. Macgregor mentioned that one way of increasing the recruiting of the Army was to offer the inducement of increased pay. There may be, perhaps, some Officers here who have commanded regiments, and who will, I think, agree with me that the pay of the soldier, at the present moment, is as high as you can safely make it. I mean the present class of soldier. If you increase his pay, what will he do with it? Unless you can make regulations which will bind him to lay aside a portion of his pay, so that he shall not spend it whilst serving, in order that it may be paid to him, or laid out to his advantage, when he leaves the service, what other good use will he make of it? The men you are getting now, come from that class of society that does not know how to make a proper use of their wages. I would almost challenge contradiction, from any Commanding Officer, when I say that it is not advisable to increase the actual money given into the soldier's hands. It may be possible, of course, to increase his comforts, and so render the position of the soldier more attractive; but extra pay, I venture to think, would not conduce to the discipline of the Army. The prejudice against a soldier's life, which has been

stated to exist among parents, is not confined to boys in reformatories. I am sorry to say it is found everywhere else. We constantly hear of parents saying, when a young fellow enlists in the Army, "He is a gone 'coon; he is done for for ever," and they will do everything they possibly can, as a rule, to get him out of the service and back to themselves. The too general opinion is that a man does not better himself by enlisting—that is the feeling of the present day. Then, again, Mr. Macgregor spoke of taking them from the age of fifteen to seventeen. The question is, at what age should recruits be taken? I do not approve of the present mode of enlistment, in which a fellow can say he is eighteen, when he is not sixteen, which we know occurs every day. Probably, the medical department would be the most competent judges whether a man was efficient or not; but, looking at the question of expense, of course I suppose you calculate upon enlisting a very much larger number of boys than are at present enlisted. At present there are only fourteen allowed in each regiment; but, by your system, there would be a much larger number of boys enlist from fifteen to seventeen. At what period is it expected that they will become efficient soldiers?

Mr. MACGREGOR: At eighteen.

Sir CHARLES DAUBENEY: I mean capable of carrying rifle, knapsack, and everything belonging to them. I know very well in foreign armies they do not enlist under twenty, but I am sorry to say we get too many young soldiers in our Army at present; at the same time you must take into your consideration that for a certain number of years, *i.e.*, until they attain the age of nineteen at all events, the public will have to pay for boys who are practically inefficient solders, and it is a question how far that could be allowed to enter into the calculations of the War Department, who would certainly object to pay for so many under-aged lads. The rule is to allow a certain number of boys in every regiment; if you put in too many of them, then the public are paying for so many boys under age, who cannot be called efficient soldiers. I merely mention this as a matter for consideration. I do not think that the deficiency of stature which you have mentioned is of so much consequence. In the regimental schools we train the boys of the regiment, sons of soldiers, and I am bound to say as a rule,—and I think every officer here will corroborate me,—that the sons of soldiers in the Army are generally a very stunted race; how it happens to be so I do not know, but they are generally shorter than others; and, of course, we must take into consideration also their appearance in the ranks. I do not think they are less efficient soldiers, provided they have the requisite physical strength, and I do not attach so much importance myself to the question of height or stunted appearance as some people do. Of course it is advisable to have men of a certain stature, and I presume that all the boys would not be of the stunted stature mentioned; and I think a great many of them would turn out very good soldiers. At all events, with regard to my experience at the Reformatory at Feltham, I must say I saw there as fine a set of boys as I ever could wish to see. I have often expressed a desire that the Commanding Officers of regiments would take the trouble themselves to pay a visit to these places, to see the way in which the boys are trained, and observe the moral culture which they receive; and if they did not find that those boys are actually more fitted, in a moral point of view, to enter the Army than the recruits picked up in the streets every day of our lives, I shall be very much surprised to hear it.

The Reverend SYDNEY TURNER: I came here to be a hearer rather than a speaker, but some things stated induce me to offer a few remarks on the subject which Mr. Macgregor has so ably handled. I suppose there is no question as to the expediency of what Mr. Macgregor proposes. Everybody must feel anxiety at the great deficiency of the military force of the country, and the difficulty there seems to be in recruiting it, and everybody must be anxious for any plan which will give us a greater number of soldiers and more efficient ones. For myself, although a clergyman, having the highest possible respect and admiration for the Army, and thinking that a soldier's duty thoroughly performed, entitles him to the respect and trust of all his countrymen, I should be very glad to see their number very largely multiplied. Speaking from my particular sphere of experience in Reformatory and Industrial schools, I may state that a considerable number have passed from a few particular schools into the Army, but still they are but a small portion of those

who might have done so. Nearly 28,000 boys have left reformatory and industrial schools since I undertook their superintendence in the year 1857, of whom more than half have been young lads that have left at the age of from seventeen to twenty. But while nearly 4,000, or 14 per cent. of these have gone to sea, only 681, that is, about 2½ per cent. have gone into the Army; and yet I am quite sure I could verify what has just been said, that scores and hundreds of them had everything in their *physique* and good habits to warrant the belief that they would make good soldiers. And more than that, they had just that impatience and restlessness of character, and that wish for excitement and action which require the guidance and restraints of discipline; they were just the persons who would do well in the Army, and probably would not do so well in trades or other occupations where they would be left to their own wills, and be without a controlling influence exercised upon them. Hundreds of these lads, too, have been Irish lads, who, it might be supposed, would be more easily induced to adopt a military life than any other. Yet, as I have said before, hardly two and a half per cent. of these lads enter the Army. I ask myself, why? and I think there are two or three reasons which partially, at least, explain the question. In the first place, they do not like constraint; they have had a full share of constraint while in the school, and they know enough of the regiment to be sure that they will have to submit to a still greater degree of it if they enlist, and they prefer their own independent action to obedience to the will of others. The next thing is, they commonly hear from their friends that a soldier's life is, after all, but a poor trade as regards making money, and the liberty of spending it. They may know, indeed, that they will be fairly fed and housed, and have a great many comforts provided for them, but these are such as perhaps many of them do not value, and they know, as far as the question of getting or saving money is concerned, the soldier has about the poorest chance of all, and so as to promotion and getting on in life. They know that if they become sailors, and behave well, they will be promoted gradually to first class men, and may attain, as scores of them have done, to the position of mates and assistant officers; they have had a very fair education, and are very often intelligent, and if they have but character and steadiness they can reckon on getting on. They know perfectly well if they work hard at a trade, or go abroad as emigrants, they can do very well; they can manage to get from twenty shillings to twenty-five shillings a-week, and in many lines of life still more. They do not think, therefore, that the soldier's trade is worth having in its money value. There is now, too, the question "What will it lead to?" If I become a soldier for five or six years, I shall unlearn a great deal of the industrial knowledge which I have learned. I shall lose much of the skill I have gained; I shall get out of regular working habits; I shall have to pass the great part of my day in doing very little in the way of active continuous labour, and at the end of my six years' service, when I shall have the option of being discharged I shall probably be pretty well sick of it, and while I shall be half spoiled for many of the other avocations of life by the particular training I have gone through, I shall not probably be so captivated with what I have gone through as to stick to the Army, and make it my permanent profession. Then there is another drawback—there is so little to excite them in the business of a military life. There is very little chance of actual employment in war. There are but few chances of promotion or distinction; the greater part of the soldier's life is spent in ordinary routine, and there is little to arouse his interest or to stimulate his ambition. Now a lad going out to sea has always something or other to keep up his interest, and a man in a common department of life has always more or less of an object before him, something which he can gain to make his position better. It is hardly so with the private soldier. I do not wonder, therefore, that the youths who are trained in reformatory and industrial schools are generally so little disposed to enter the Army. I doubt whether a school established specially for the purpose of military training would answer so well as Mr. Macgregor might be inclined to expect. If the boys are to be sent to it under any kind of compulsion or constraint they will look upon it as a means of additional detention or imprisonment, while if they are left to their own inclinations, and are invited to volunteer for it, I think that for the reasons already stated very few will be disposed to enter. But I think that there might be more inducement given to pauper as well as to

industrial and reformatory schools to train their lads as soldiers; to infuse a more military spirit into them, giving them not mere dry details of drill, for the purpose of enforcing obedience, and making them more exact and punctual, but training them to a discipline of order, alertness, activity, and endurance, with something of an intelligent idea of its use and value. I cannot help thinking that the schools might well be more encouraged to do this, and to aim at leading and training their lads to military service, and stimulating them by prizes and distinctions to enter it. It is proposed to give special aid and encouragement for training boys for the mercantile marine through the Board of Trade, and for the Navy through the Admiralty; and it seems to me that it would be equally worth while for the War Office to give premiums and encouragements to the large schools which are supported by charity, or by the public rates and taxes, and which contain boys capable of being brought up in the Army, to induce them to exert and interest themselves more in promoting the boys' enlistment, and in leading the boys to take a fancy for a military life. I see Captain Brookes present, who has this great institution at Feltham under his superintendence, and probably there is no institution that has been superintended with more ability and earnestness, or with more credit to its superintendent. Feltham has a very much larger number of elder boys than most other industrial schools have, and as Sir Charles Daubeny has said, a very considerable proportion of these lads are such as one would like to see going into the Army. Very few of them, however, do so, except a few who are trained as musicians, and enter regimental bands. I should be very glad to hear from him, whether he thinks that these lads could be induced to enter military service under present circumstances, robbed as it is now of so much of its old romance, and invested as it is with a great many rather discouraging prospects in a commercial point of view if more encouragement were held out to them, and the school training were more specially adapted to interest them in the soldier's profession, and prepare them to succeed in it. As to the weight to be allowed to the objections made by parents to the enlistment of their children from the schools, we must after all put ourselves in other people's places. Although we might have misconducted ourselves, we should not quite like our children to be taken from us against our will and made soldiers, sailors, or what not. I think every parent has a right to object, and make reasonable objections. It is but fair, for the sake of the boy himself, to give to some central authority the power of judging of these objections, and, under certain circumstances overruling them; but it would scarcely be right to sanction the enlistment of a boy for the Army, or the putting him into the Navy, or the sending him out as an emigrant directly in the teeth of his parents' wishes, except in two cases; the first, when he is above sixteen, and can therefore act for himself, and has a right to judge for himself; and secondly, when his parents are of that thoroughly profligate kind, and have so utterly neglected him that they have lost all right to control. Under those circumstances society has a right to say, "The parental bond is fairly snapped, and we, as guardians, have a right to supersede the parents altogether," and to consult only the advantage of the boy and the welfare of the community.

Captain Brookes: I am more accustomed to act than to speak, and came here to-night without any intention of making remarks. My feelings are of a mixed kind with reference to this matter, for I have my doubts and I have my hopes about it. My doubts are, as Mr. Turner has said, that I think boys would kick a little against going into a second school after leaving a first. It appears to me possible that Mr. Macgregor's plan could be modified by establishing smaller schools under the new system of brigade depôts, so that each depôt might be allowed to have a small number of boys about 16 years of age attached to it, who might eventually become soldiers, and who, if they did not come up to the requirements of the Commanding Officer could be dismissed. Perhaps some tentative measure of this sort could be carried out. At Feltham, where I have had the honour of being in charge for some years, I have endeavoured to introduce a kind of *quasi* military system and spirit; and, having belonged to a service which is said to be neither fish, flesh, nor good red herring (the marine artillery), I have consequently had some experience of military and naval life. I prevailed on the magistrates (who are the Committee of visitors) to start a land ship from which we send 70 or 80 boys annually into the mercantile marine, and also to organise two bands, by means of

of which we place about 40 boys yearly in the Army. I must speak most thankfully of the Horse Guard authorities, who have always been most kind and obliging and anxious to promote the enlistment of boys. The late Inspector-General of recruiting, General Edwards, very kindly came down and saw the school himself, expressing his entire approval of everything. He also authorised me to forward lists of the boys ready to be engaged; but I have not found it necessary to do this latterly, because the demand for boys has been larger than we could supply. Here and there a boy turns out indifferently, but the great mass turn out well. There are several General Officers who take a special interest in the training of the boys connected with our school. The lads take very readily and willingly to drill; and, although I do not like to say too much of ourselves, I am sure any military gentleman, who has seen our little battalion march past, must acknowledge that they do their work well. We have had such men as Colonel Battersby of the Military Asylum present, who was kind enough to say he thought our drill was quite as good as his own; and I could not expect him to say more than that. I think if some sort of system could be adopted by means of which a certain number of boys could be received at the brigade depôts, who were calculated to make good soldiers, and who could receive a certain amount of industrial training in tailoring, shoemaking, saddlery, &c.; then these boys after a year or two of training could be made very valuable adjuncts as pioneers, &c., when they were drafted to a battalion. I regret to say, however, I have not given the subject the consideration it requires. Mr. Turner alludes to the point of parents refusing consent to the enlistment of their sons. It is certainly very annoying when you see a smart young fellow who himself says he would like to enlist, but, because his father will not sign the paper which is necessary to carry out this desire, he cannot do so, because he is under 16. Indeed, it so happens that the age fixed is extremely awkward, as the age for the enlistment of boys in the Army is from 14 to 16, and the "age of nurture" (as I think it is called) does not cease until the latter age; consequently, when a boy can act for himself, he is beyond the term for enlisting as a boy, and not old enough or physically fit to enlist as a recruit. If, however, the Army could extend the age to 16½ instead of 16, so that the boys between 16 and 16½ could sign their own contracts, which they would then be legally competent to do, this would remove the difficulty complained of to a great extent; and I would observe that the Navy already take boys up to 16½. I would only say if any gentleman can find time to favour us with a visit at Feltham, we shall be very happy to show them what we are endeavouring to do there.

Mr. WALLACE (in response to the invitation of the Chairman) said:—I do not know on what point I can contribute any information after the paper we have heard read, and the discussion that has taken place. I would only note what Mr. Turner said about reformatory schools. Upon that subject, unfortunately, I have no experience at all. I do not know how it is that so few boys enlist from the reformatory schools, but I do know that a great many boys in industrial schools express a desire to go into the Army, a desire which they are prevented from carrying out by the regulations which prevent boys between 16 and 18 being admitted into the Army. It may perhaps be the hope for the unattainable which makes boys of 16 profess to desire to get into the Army, and to complain against the restrictions which exclude them. I cannot, however, say anything upon that subject, and reformatory schools I am not at all acquainted with.

General Sir WILLIAM CODRINGTON, G.C.B.: This is not merely a question of schools. We might all wish, if possible to get the same kind of schools for the Army that have been so successful for the Navy, but we can understand the different inducements held out. The Navy are better paid, that is one point; they have short voyages, that is another point; and, as one speaker has said, they can get on in their line more rapidly than they can in the Army if they enlist. Of course the question is intimately connected with the general system of recruiting; but where you have a parental system how is it possible that you should enforce upon those who are to be put into these schools, the necessity of entering the Army. You do not do it in any other class of life, and I do not think it could be enforced even with State education in these schools. I think that would be the difficulty, and I do not know whether the Lecturer can show any means of getting rid of it. Then as to the

general system of recruiting, what is there to induce a man to go into the Army? Is it the pay as compared to the pay of civil life? We all know that it is not so. His pay is certainly very inferior; even with all the advantages of lodging, fuel, light, &c., his pay is positively inferior in point of money. Then what do you insist upon for that pay, small comparatively as it is with regard to that in civil life? You take him for ten or twelve years from his country to India. You take him to a barrack where he cannot say his life is his own, or any portion of his time if the the public service requires he should give it up; and, with all this, you are to induce a man to enter the service voluntarily. Again, it may be asked, what is to induce a good man to enter as a soldier? In time of war there may be a certain quantity of excitement, but the facts show that in time of war there is even a greater difficulty in getting recruits than in time of peace. I think that was the case in our last war, and at all events if you do get the numbers, you certainly get into a lower stratum of society to supply the great demand there is in an Army on active service. I should be very glad if Mr. Macgregor will be kind enough to tell us how one is to get over that question of a sort of apprenticeship or enforcement of their going into the Army from these schools. With regard to the small size of the boys mentioned, if that is the fact, surely that is one great drawback to their going into the ranks. I mean if they are so very small. The boys that are spoken of may do for bandsmen; and, if they play well, it does not signify much that they are defective in height; but for the ranks it is a question not only of height but of positive physical strength to march and carry weight. Having regard to this, I think it will be found the very small men—the boys that Mr. Turner was speaking of, of about 5 feet 3 or 4—come below the mark we wish to see in the Army for the necessary purpose of carrying weight and active marching. Although this discussion is rather limited to one point, we, perhaps, naturally get into the general question of recruiting; but with regard to the schools I am afraid it is impracticable to carry out the inducement to enlist, which is either a question of money or the enforcement of it as a matter of compulsory apprenticeship.

Sir CHARLES DAUBENY: The boys I allude to, though short as boys, do lead to good men of 5 feet 6 eventually, and I think 5 feet 6, if they have physical capacity, is not a bad height.

Mr. TUFNELL: That is what I meant. I published a list of the heights of all these children, and it is certainly low for 14.

The CHAIRMAN: I think what Mr. Tufnell alluded to was the smallness of the boys when they were boys at school. If I recollect right, you said they were 4 feet 2 or 3 at the time. I know there have been objections made when boys have been proposed from some of these schools that they were so exceedingly small and diminutive that they gave no pospect of growing into able-bodied men. But, then, they were only 14 years of age or a few months older. Mr. Tufnell's experience is mine also, but I think that is what Mr. Tufnell meant.

Mr. MACGREGOR: The number that would be possible to obtain, must be after meeting all the objections. If we had to deal with hundreds only, the objections that have been mentioned would have brought them down to something too minute to consider at all. We are dealing with tens of thousands, with hundreds of thousands, and after taking away all that are physically unfit, and after excluding those whose parents will not consent, we still have thousands of boys who cannot get in; because, at 16, they cannot be enlisted, and if they could get in, we know for certain, a number at 18 would be ready and fit to enlist, and these are asking for admission and cannot obtain it now.

Mr. Tufnell's numbers, with respect to those who enlisted from the metropolitan schools, differed from mine for this reason. I took the numbers only from those schools that wrote to me, and those were outside the metropolitan district as well as at home.

The consent of the parents is, in my scheme, absolutely necessary. At the age of 16 any person, a boy or girl, has power to act without the consent of their parents. I would throw all doubtful cases away; and, though I should be sorry to leave out the boys whose parents would not consent, their objection to consent would probably be removed when they saw other boys coming in and being well treated in our establishment.

As to the age, some little mistake was made about that by some speakers. The proposal in my paper is that boys should be *received* from 15 to 17, but that none should be sent into the Army till they are clearly 18. If it is objected that such lads are too young, then all your present recruits may be too young also, and any person can get in at that age. I propose that only a certain number of selected and willing lads should be taken, and out of the 5,000 that I believe are available yearly, I suggest that 500 might be tried, so that the margin left for unexpected difficulties is very great.

Mr. Turner speaks of the boys not being likely to come from one detention or another. I perfectly understand that. Mr. Wallace, myself, and others, who visit these institutions know a great many will not come at the *end* of their term; and it is for that precise purpose I put the years of admission from 15 to 17, because many of the lads that have been two years in a reformatory would gladly go to an Institution of this kind if a year of the sentence were remittted them. Some would come from outside, some from refuges, and some from reformatories where you can keep them to 20—some from industrial schools where you must discharge them at 16.

With respect to what Captain Brookes said, that such things might be done on a small scale, the trial might be made on a smaller scale still, you might try fifty boys at the brigade depôts. But there are many objections to that. On another point we know that in industrial schools there are cases voluntarily paid for alongside the boys sent by magistrates, and that both classes get on together uncommonly well. In one school in London we have about one-third voluntary cases who go out into life after being trained along with these other little fellows from police courts. I believe it has an excellent influence on both kinds of inmates, and it keeps the Institution from having a "prison feeling" to know that there are many present who can be taken away by their parents or patrons at any time. But as for enforcing enlistment of the lads, if the inducements do not bring them willingly, this project falls to the ground.

I would therefore ask you in some degree to consider the proposal. Though very small it would at any rate do something. It might be a good example, although it could not be expected to be multiplied by ten at once. If out of these 5,000 you could not get 500 boys, first rate in appearance, character, physique and willingness, then of course imagination has led one into a poetic vision which ends in smoke.

The CHAIRMAN: I think, gentlemen, the Lecturer is entitled to our best thanks. This very interesting lecture which Mr. Macgregor has been good enough to give us has led to a still more interesting discussion. A great many points have been raised which I think are well worthy of consideration, and there are one or two small items on which, perhaps, I ought to say a word or two, as I occupy a sort of official position.

Everybody will admit that nothing can be better, if it can be carried out, than to feed our Army with well-trained youngsters. I am quite certain they turn out the best recruits we can possibly get. There is one branch of our service which many present will bear me out in saying has been enabled to carry out the system more thoroughly than any other, and that is the Royal Artillery at Woolwich. They have a large stationary establishment at that station, with numerous facilities and advantages, and the result has been most excellent. Many of those who are best qualified to judge, old Officers of artillery, Staff Officers, and others, have assured me that the greater proportion of their best non-commissioned Officers have been boys very often born, but almost invariably trained in the regiment. At Woolwich they have many facilities for giving boys a good education and teaching them trades, while they are not shunted about as regimental boys in cavalry and infantry regiments would be from one place to another. It may therefore be taken as a model of what we wish to do for the rest of the Army. For my part I should be only too glad if I could see every one of these new brigade depôts turned into a training establishment for boys. I should like to see 100 boys at each of these 70 depôts. But then comes the question of money, which crops up on every occasion; and I think there are some here (Major Wilson amongst others) who could testify how great the expenditure would be if my proposal were carried out—the buildings,

schools, teachers, and other matters would run up the expense to something that no Secretary of State would face. The principle of taking boys is excellent, but, unfortunately, as the regulations now stand, we are completely debarred from carrying it out to the extent we would wish. The regulation is one boy per cent. of the rank and file of the Army. That is but a small proportion; even to a full regiment on foreign service it only gives ten boys. The supply of boys is so large that I venture to say we could get any number we liked—we may pick and choose among our different establishments—and you must recollect that besides the usual applicants we should like to provide for, we have the Royal Military Asylum, the Hibernian School, and the vast number of soldiers' children who really have a claim upon the service before outsiders. I consider that the difficulty is to get vacancies, not boys. We could get a dozen, fifty, a hundred boys for every vacancy we have to put them into, but the question is will the authorities and the Chancellor of the Exchequer stand it? I know on one occasion I happened to be present when the Secretary of State, the Commander-in-Chief and others in high authority were talking over this very subject. They all said—"Yes, we must have more boys;" and the Commander-in-Chief said—"Oh yes, by all means, but they must be supernumerary to the establishment, as for every boy added to our ranks I lose a bayonet." The Secretary of State retorted—"It is a most excellent plan, but I cannot have "them extra to the establishment—we cannot stand it in the Estimates," therefore the question of the boys fell through entirely. I think if we could establish something like what Mr. Macgregor has so ably put before us, we might meet a good many of these difficulties; but then, again, it is a matter of money, because this establishment or school cannot be supported without some Government help. Of course Government will not pay money without some equivalent, that is to say, they won't keep a boy for two or three years without getting any service out of him then or subsequently; therefore the question of enlistment or apprenticeship which I think Mr. Turner alluded to is absolutely necessary. If these boys enter this establishment they must go with the full idea of carrying out their engagement which is to serve Her Majesty. As to the difficulty of getting boys to go there, there is not the least disinclination on the part of boys generally to join the Army. But we must remember in the Army it is a different thing from the Navy. In the Navy there are various employments and avocations in which a boy can be equally well if not better employed than some of the men on board ship, and there they are always under supervision; in fact they can be made useful at a much earlier age than boys for the Army. Besides, every man in the Army is supposed to be fit and able to undergo the fatigues of a campaign; and therefore we could not burden ourselves with a number of boys unless they were kept in a sort of institution such as Mr. Macgregor alludes to until fit for the ranks. There has never been any lack of boys to fill the vacancies occurring in the service; but I am afraid the question of £ *s. d.* is one we must get put forward by some one who can persuade those who hold the purse strings to let us have something given towards the necessary expenditure.

I am sure you will all join with me in thanking Mr. Macgregor for his very able paper.

Evening Meeting.

Monday, April 19th, 1875.

COLONEL H. C. FLETCHER, Scots Fusilier Guards, in the Chair.

NAMES OF MEMBERS who joined the Institution between the 5th and 19th April, 1875.

LIFE.

Stanton, F. Robt., Capt. late Royal Scots.
Domville, W. C. H., Lieut. R.N.
Fraser, Thomas, Capt. R.E.
Markham, Edwin, Major R.A.

ANNUAL.

Trevelyan, H., Lieut. 32nd Regiment.
Northey, W. B., Lt.-Col. late Cold. Gds.
Marriott, W. F., C.S.I., Major-General.
Colquhoun, J. A. S., Capt. R.A.
Mansell, A. B., Lieut. R.N.
Robertson, Murray, Capt. West Kent Militia.
Abbott, James, Major-Genl., R.A., C.B.

"THE GATLING GUN; ITS PLACE IN TACTICS."

By Captain E. ROGERS, F.R.G.S., Staff Officer of Pensioners, Chester.

WAR has become so terrible from the increasing powers and accuracy of fire-arms, that a proportionately keener interest is manifested in movements technically termed tactics, which tend to secure a certain degree of safety in the field whilst inflicting the utmost amount of injury on the foe in the shortest possible space of time; for the ancient conditions of fighting are reversed, and instead of movements leading up to some grand and supreme effort whereby the enemy, gradually intimidated, was finally crushed by an overwhelming advance in compact columns, modern tactics seem to court immediate contact in the loosest formations—and the sooner the better.

Now as the Gatling, like all mechanical contrivances, seeks to supersede manual by self-acting labour, or in other words to economise the human life that must be sacrificed at the outset of a battle or campaign carried on by an enterprising General desirous of sudden success, the question of tactics is for it of paramount importance, and demands special consideration, inasmuch as I venture to contend that by a judicious employment of this means to the end, the hitherto awful loss of men in primary actions will be brought within a minimum compass on the side of the combatants availing themselves of such retaliating substitutes. I was present in this theatre two years ago, when Major Henry Brackenbury delivered a most impressive and exhaustive lecture on the "Tactics of the three Arms," and we might naturally have expected then to hear something reliable as to the action of automatic fire-arms in warfare, but on that point he was silent; and although I was invited by the Chairman of the Council to provoke discussion on so important an omission, it was impossible under the circumstances to avail myself of the opportunity. And yet the gallant lecturer as well as his equally distinguished

brother, who was present and took part in the discussion, could on that occasion, as at other times before and since, have spoken to the powers of machine guns and descanted on their utility for service with perhaps more authority than most living Englishmen; for one of them at least personally witnessed the startling performances of an inferior nature of mitrailleur, handled with little judgment and opposed to a foe tactically as well as numerically superior. It may be said that the question of the employment of mitrailleurs in modern warfare, ably handled as the subject was by Dr. Gatling, Major Fosbery, V.C., and Colonel Fletcher, Scots Fusilier Guards, has been already discussed within these walls, and an open verdict given on their general adaptibility; but it is because the lectures alluded to were delivered at a time when the system was not thoroughly understood that once more the question is submitted to your judgment; and moreover we have added the sober reflections of three years to our knowledge of the gun.

I have, therefore, compiled this paper not as an exposition of dogmatic theory (however enthusiastic it may appear), but with a view to elicit the experienced opinions of others, and thus to gain for the members of this Institution and for the Army at large, the most authentic observations on an increasingly interesting subject. The title of my lecture will accordingly be pretentious in so far only as you respond to or decline the invitation. To effect this object I propose to consider present tactics as enforced by the experiences of modern warfare, interpolating suggestions as to the position of Gatlings, and thus with your assistance and corrective criticism to arrive at some conclusion affecting their status; for, individually, I hold that the Gatling battery should be regarded as an entirely separate and unique organization; as, in fact, a fourth arm of service. But before entering on the vexed question of tactics, I may be permitted to make a slight historical retrospect, so as to lay before you the facts connected with the introduction of the Gatling gun into modern armaments, a weapon, be it remarked, thoroughly and essentially different in all its distinctive features from all other fire-arms. It was the introduction of rifling, coupled with the uncertainty of fuzes, that brought about the necessity for an intermediate arm of service. "By depriving it of its most destructive projectile, can-"ister," says Captain Henry Hime, in his *Artillery* prize essay, "rifled small arms have inflicted a heavy blow on field artillery, but "the evil is not irreparable, for the mitrailleur is capable of delivering "a fire of case far more extended and deadlier." The year 1869 was marked by unusual activity among nations in the investigation of rival systems of multiple guns.

But it is not my purpose to weary you with descriptions of the different mitrailleurs (as they came to be called, a generic term which by the way is apt to mislead) that were then previously or subsequently brought forward. No doubt they each had or have some speciality worthy of the inventor, and a principle may be correct which is simply spoiled in application; but my contention being that this "principle" has reached its culminating point in the Gatling

gun, I must confine myself thereto. In July of that year (1869), Gatlings of the larger calibres were experimentally reported upon both on the Continent and in America, and verified their unique character for continuity, rapidity, and accuracy of fire at long and short ranges. These were excellent results under the circumstances, and with the poor and imperfect ammunition of the period. It has, indeed, been to the simultaneous improvement of metallic-case cartridges that machine guns owe their present marvellous rapidity and certainty of discharge. In the following year it was ascertained by a special Committee, from a comparison of a series of trials carried out at Shoeburyness, under various conditions in regard to time and distance, that the destructive effects of a Gatling of small-arm calibre would be nearly three times greater than that of the 9 lb. field gun at troops in the open up to 1,400 yards. Moreover, the experiments clearly showed the deadly effect of this small Gatling up to 1,500 and even 1,600 yards, whilst the larger and medium sized Gatlings made good targets at 2,000 yards. These, however, were broad results of trials on level ground, without the distracting elements of strife, and could not be said to affect the particular hypothesis that machine-guns skilfully, courageously, and intelligently manipulated, would prove themselves unrivalled as death-dealing instruments amid the confusion and excitement of the battle-field. A second Report was therefore drawn up by the Committee on the 21st November, 1871, when the evidence of eye-witnesses to the action of mitrailleurs could be brought to bear on the question of their employment.

But the war that raged in the interval was not particularly conducive to the practical development of machine guns, because of the fact that no special preparation or tactical training had been devoted to the subject by the French Artillery Executive. The mitrailleur so mysteriously unveiled at Saarbruck effected but little to establish its reputation; and although on several after occasions, good service was performed by mitrailleur batteries, as at Wörth, Gravelotte, Beaugency, Sedan and Metz, the general results fell far short of Napoleon's, and, may I not add, of the world's expectations? It has, however, been remarked by more than one writer on the Franco-Prussian war, that French gunners were the least likely to do justice to a novel weapon of the kind, and to work it with calm intelligence. Be this as it may, the guns were not Gatlings, but mitrailleuses.[1]

On the other hand, the Prussians were content with their superiority in numbers and discipline, and dispensed with machine guns, except in the Army of the Bavarian Contingent, by whom a nondescript species of revolving cannon was nevertheless at times used very effectively.[2]

[1] A few Gatlings were, it is true, employed in the campaign of Le Mans, and at the siege of Paris, but they must have been of a crude and obsolete pattern, for the Emperor had some time previous to the war refused to purchase 100 Gatlings of an improved model offered to him by the Gatling Gun Company.

[2] "It produced a marked result at the affair of Coulommiers; one battery of four pieces causing, firstly, a battery of guns to retire when at a distance of from 900 to 1,000 yards; and further, repelling three times the attacking columns of the enemy."—Report of the Swedo-Norwegian Artillery Commission, 1872, translated by Captain King Harman, R.A.

The Prussians also captured a large number of the French type of mitrailleur, and when some of these were subsequently tried at Berlin, in competition with Gatlings and Montigne mitrailleurs, they were pronounced superior to either;—"an admirable conclusion to arrive at, "so far as economy is concerned," observes Captain Owen, in his recent pamphlet on Machine Guns, "but one scarcely borne out by "unprejudiced evidence." Major Charles Brackenbury may also be quoted on this head. He says:—"The Prussians alone, so far, deny "their value in the field, though they admit it for sieges. But the "Prussians never admit the value of anything that costs money, until "they possess it; and I can vouch for the fact, that the soldiers held "the French mitrailleuses—unwisely used though they were—in more "dread than the French Artillery." As however, it has, more than once, been broadly asserted, that mitrailleurs are regarded by Prussian Officers as superfluous engines of warfare, it may here be well to quote as evidence to the contrary, a few passages from the official work on the Franco-Prussian war, edited under the supervision of Count von Moltke, as translated by an Officer of the French Staff. In the great tactician's account of the battle of Gravelotte, he states:—"While "the action was thus developing upon the principal line of battle of "the 3rd division, three battalions of the advanced guard were having "a partial engagement in the vicinity of Chautreune. Two com-"panies of the 36th regiment had been led from Chautreune to the "slope which rises from the east, but, as in the wood, they did not "succeed in pushing further forward, for the open ground was entirely "under the fire of the French infantry, posted in the same wood and "in the cluster of trees west of La Folie and Montigne-la-Grange; "from this point notably, a battery of mitrailleuses swept the border "north-west of the cluster of trees, and another battery from the "south angle of this cluster, held under its fire the clearing which "separates it from the Wood des Genivaux. In a short time, General "v. Blumenthal saw the impossibility of an attack upon La Folie. "* * * * The position of the 36th Regiment on the open ground, "afforded it very little shelter against the enemy's musketry and "mitrailleuses, so its losses gradually reached a very high figure, while "the French generally kept themselves defiladed, or outside of the "zone of action of the needle gun." Further on he says:—"At this "moment the Artillery in position on the ridge to the south of the "Wood de la Cusse, was placed in an extremely critical situation. A "battery of mitrailleuses had debouched in front of d'Amanvillers, "and fired directly and with excellent range upon the extreme left of "the line of Prussian Artillery. This point was occupied by the "fourth heavy battery, already seriously injured by musketry; in a "few minutes the fire of the mitrailleuses so decimated it that several "Officers, 5 chiefs of pieces, and 40 men were disabled, and nearly all "of the horses were killed or wounded. Such was the situation when "suddenly large detachments of the enemy's infantry rose from the "ravine in front of the ridge, and threw themselves, with surprising "swiftness, upon the defenceless battery. Its chiefs already wounded, "succeeded, with the few horses still untouched and after desperate

"efforts, in getting two pieces back to the border of the wood; but "the remainder of the pieces fell into the enemy's possession."

Now, the foregoing is, I take it, a very suggestive quotation, and it is clear that on this occasion the French displayed exceptional good judgment. It will, however, be sufficient to draw attention to the fact that the 36th Regiment suffered losses from the mitrailleurs at distances beyond the effective range of the needle-gun, and also that guns of heavy calibre, in position, were completely snuffed out by volleys from another mitrailleur battery, stationed on an exposed ridge.

In accordance with the advice of Colonel Wray's re-assembled Committee, two natures of Gatlings were tentatively admitted into our service, namely, the one of ·65 calibre, for naval purposes and coast defences, and the ·45-inch, or ordinary Gatling, for field service. The Committee could, indeed, find no real fault with the former gun as a far-reaching and excellent machine for field service when opposed to artillery, but they thought that the weight of ammunition required to produce the highest results, under exceptional conditions, rendered its adoption inexpedient. Of course, so heavy a gun would, like the French mitrailleur, require more than two horses for its draught; but, in this connection, it is proper to remark, that the improved American Gatlings of large calibre, weigh considerably less than they did in 1871, that of ·65 calibre being 450 lbs. only. The difference of range between the small-arm gun and those of large calibre firing heavy projectiles, should also be borne in mind, when it is considered that our Gatlings may be opposed in the field to long-range mitrailleurs, such as the French ones, and not being able to reply to them, would be as discouraging as to be subjected to a distant cannonade from shell guns. It is, in fact, no longer possible to ignore the existence of mitrailleurs with the armies of all countries, every State in Europe having adopted some type of machine gun. Other nations have anticipated us in the extensive adoption of the Gatling for field service. Even Turkey and Egypt, China and Japan, Tunis, and Morocco, have procured armaments of this description, but Russia in particular possesses a formidable array. 400 Gatlings formed into batteries of 8 guns each, attached to the artillery branch of service, are, according to the information of our Intelligence Department, distributed as follows:—328 are stationed in European Russia, 48 protect the Caucasian territory (one of the batteries being assigned exclusively to the Cavalry) and 24 are placed in Eastern Siberia and Turkestan.[1]

[1] Why the Gatlings in Russia were named "Gorloffs" had better be explained, and indeed I have been requested by General Gorloff to disclaim, on his part, any pretention to the title of inventor. There is a rule in the Russian service that the name of any official superintending the casting or construction of a gun must be engraved on it. Hence the erroneous notion that General Gorloff altered in any way the mechanism of the Gatling. While at Hartford (United States of America) superintending the construction of the Gatlings for his Government, he experimented largely with the cartridges of the Berdan rifle (which is in partial use in Russia), and he succeeded in effecting an assimilation of ammunition (an important and economic provision which we would do well to imitate), but he did not tamper with the gun. Considerable changes, but no radical one, have been introduced in

During the Khivan Campaign, two Gatlings only were employed, but that they did good service may be judged from the following among other instances related by the Russian Officer, who had direct charge of the subdivision of the battery, as quoted by General Franklin, late U. S. Army, in a pamphlet lately published in America:—"About 3 P.M.," says Captain Litvinoff, "parties of horsemen commenced to make their appearance from different sides; they "approached us nearer and nearer, and behind them we could descry "larger masses. They commenced to engage our picket line with "great determination and daring. One of these pickets, composed of "1 Officer and 5 Cossacks, sword in hand, threw themselves forward "against an approaching mass of Turcomans and were completely cut "to pieces. Two companies of the 3rd battalion of sharpshooters, "two of the 8th battalion of the line, and two battery guns (Gatlings) "were ordered forward to drive away these bands of Turkomans. "The road we had to follow was very difficult even for infantry and "cavalry, as at every step we had to cross wide ditches, dug for "irrigation, which had abrupt sides; *for artillery the road would have "been impassable.* Our light battery guns went on this road with "perfect ease, the ammunition pack-horses alone giving us some "trouble. When we stopped, a line of sharpshooters and battery "guns was formed along one of these ditches. First I had to find out "the range; for this purpose I fired three cartridges, changing each "time the height of the sight; the distance found was between the "limits of 1,050 and 1,170 yards." Then he goes on to tell of his dispersing the smaller bands of Turkomans with very few rounds:—"Opening at the first, I fired rapidly 25 rounds; the band immediately dispersed, part of the men joining the second band. Opening from the second gun, I fired 50 rounds without interruption; "the second band dispersed at once, and the men betook themselves "to broken ground."

However, later they still came on:—"Several times the enemy "collecting in masses of some strength moved against us, but was "each time driven back by our fire; thus I had several opportunities "of firing a succession of 25 or 50 rounds, the direction of guns and "their elevations varying somewhat according to circumstances. In "the whole, the battery guns fired that day 408 cartridges." Not very many certainly, but the Russians had to be sparing of their ammunition as of everything else on that campaign.

But it is in the United States especially, that, as might be expected, the utility and economy of Dr. Gatling's invention has been appreciated. Two natures of the weapon have been issued to the American Navy, one with long and one with short barrels. Pivot-sockets are fixed in convenient positions on the rails and in the tops of large vessels, to enable the latter Gatling to be fired at an extreme depression for the repulse of boarders and for driving off torpedo boats. When

the construction of the Russian Gatling at the instance of a mechanical genius in St. Petersburgh, named Barononski, in whose service are the Nobel brothers (*par nobile fratrum*), whose names have, in like manner, been given to the so-called improved Gatling.

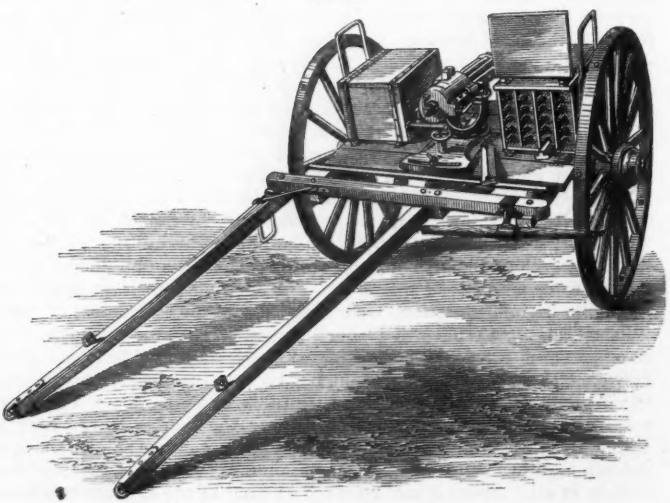
either gun is used as a field-piece ashore, 13 men are assigned to the duty of serving and manœuvring it in action, the ammunition being conveyed in reversible carriages, and the men are drilled to load occasionally by hand, each man carrying for that purpose, 100 cartridges in a "passing box," slung over the shoulders; a rate in firing of 60 rounds a minute can be attained by this process of manual feed, during any interval in the continuity of loading from charged drums or feed-cases. As in our own service, steel screens are employed to protect the crank-men in ships tops, and mountings are fitted to the bows of cutters for the reception of the Gatling when used to cover a landing, or in river expeditions. "The Gatling gun, although an intricate "piece of mechanism to put in the hands of seamen," observes Lieutenant Marvin, U.S.N., the compiler of a manual on the subject, "is not liable to get out of order in service or have its parts deranged, "if intelligent care be exercised in its use and treatment." In the autumn of 1873, a series of trials to test the strength of the improved cartridge and the endurance of the Gatling, were carried out at Forts Munroe and Madison. The inventor of the gun stood by while 100,000 cartridges were being discharged, 63,000 of them being fired almost consecutively, and at times at a rate of 400 rounds a minute, without waiting to wipe out the barrels. The only mishap that occurred during this unprecedented test of gun and ammunition, was the breaking of an extractor hook, upon which Dr. Gatling at once withdrew the damaged lock; the firing was proceeded with to the close. Further experimental practices, to ascertain the value of the Gatling, in comparison with shell guns and small-arms, and for flank defence of temporary and permanent fortifications, were concluded last year, and the published account of the proceedings of the Committee, forms a complete vindication of the weapon as an auxiliary and indispensable arm for all branches of service. One passage only, have I time to quote:—"In field fortifications," say the Board, "a gun that can deliver a "rapid and intense fire, effective at both long and short ranges, is very "desirable. Indeed the power of guns to attain an enemy's column "at a long distance, obviates in a measure proportional to their effi-"ciency, the necessity for using shell guns, or any other flanking "guns, at close range. If, in addition, this hypothetical gun shall "have proved itself capable, not only of *delivering* but of *maintaining* "uninterruptedly for hours, a most destructive fire at all distances "indifferently, from 50 yards up to and beyond a mile; its introduc-"tion into the armament of our fortifications, as an auxiliary, would "seem to be an obvious necessity. The Gatling gun is such an arm, "and is, beyond question, well adapted to the purposes of flank "defence, at both long and short ranges." In addition to a large number supplied, as I have said, to their Navy, for boat and shore service, 50 short-barrelled Gatlings have been issued for service with the United States Cavalry. Each gun is mounted on a light two-wheeled cart, so constructed as to answer the double purpose of an ammunition waggon. The cartridge boxes on either side of the gun contain together 40 feed cases, each holding 40 rounds, or 1,600 cartridges in all. Space is also reserved in front of the axle for two boxes

of cartridges, containing 1,000 each, so that the carriage can take with it a large supply of ammunition as well as the gun and a few necessary tools. [The accompanying illustrations (from photographs,) show

FIG. 1.



FIG. 2.



what a handy weapon it is for service in difficult country.] In the autumn of last year, two Gatlings were reported to have done "splendid service" in frequent encounters with the Redskins on the Western Frontier. On one of these occasions, Major Price, of the 8th United States' Cavalry, was attacked by 600 or 700 Indians, and he used his Gatlings with such excellent effect as to quite demoralize and drive off his savage assailants. Having thus summarised the history of the Gatling gun, it will be seen that hitherto the improved gun has only been employed against a foe ill-provided with artillery, or with no artillery at all; and let us consider for a moment, the advantage of such weapons for service under similar conditions in our Foreign Dependencies. It can indeed, scarcely be doubted, that as an auxiliary arm, Gatlings are peculiarly adapted to colonial defensive operations, as well as for retaliating demonstrations against troublesome neighbours, in countries where our enemies are numerous but ill-armed, where the roads are few and unsuited to wheel traffic, and where the surprise caused by the overwhelming discharge of a battery would carry with it an irresistible moral effect. More than 150 years ago, an Affghan Chief crossed the deserts of Kerman with an army, for the most part mounted on camels, a number of the latter bearing, in addition to their riders, a swivel gun. Approaching Ispahan, they encountered a Persian Army nearly three times their number and provided in addition with 24 formidable pieces of ordnance. On the Persian Army's approach, the left wing of the Affghans gave way; the former immediately pursued with vigour, but soon their enemies' ranks opened and disclosed a line of 100 camels kneeling down, each with a gun on its back. The fire knocked over the leading ranks of the Persians, and a charge of cavalry completed their discomfiture. Colonel Maxwell, R.A., who recounted this story some years ago to an audience at Woolwich, became, no doubt, unknowingly responsible for the hint as magnified by an American Artist, who has depicted an army of camels with short-barrelled Gatlings duly mounted, deployed for action on a vast plain in double ranks, front rank kneeling. The terrible effects of such a volume of volleys is, in fact, the only thing left to the imagination in the picture! But it was, I believe, at the serious suggestion of this same artillery officer, that Dr. Gatling planned the camel gun, weighing 135 lbs. only, and capable of being worked from a fixed tripod, or from the back of a camel or elephant.[1] Where range is of

[1] "In the mutiny of 1857," says Colonel Maxwell, "in India, and for some time subsequently, two camel corps, on Sir Charles Napier's model, were organised—one company being taken from the Rifle Brigade and another from the 92nd Foot.

"Could such corps, in addition to their power of locomotion, be endowed with increased power of musketry fire, their value, from a strategical and tactical point of view, would be vastly increased. Combined with cavalry, they would be more especially suitable to such operations as reconnaissances, as they would provide the reconnoitring force with precisely the element in which reconnoitring parties are usually deficient—viz., missile power and capacity of resistance in case of surprise; furthur, for suddenly seizing important strategic points such as the junction of a number of ordinary roads or railroads, fords, bridges; or for making requisitions, covering forage parties, seizing boats in a river, escorting convoys, and the like.

"As we have, in the north-west of India, a splendid breed of camels, it seems de-

secondary importance to portability, such a gun would display very valuable characteristics.

It, in fact, almost meets the requirements of Major Rait, C.B., who has suggested a "pistol Gatling" of 100 lbs. weight, to go on a light simple carriage; but as to this, I am inclined to think with Major Fosbery, that we ought not to sacrifice our command of ground and precision of performance, to the attractions of toy guns and feather-weight ammunition.

The specimen of the Gatling gun, courteously sent by Sir William Armstrong from the Elswick Works, for exhibition on the present occasion, has been expressly designed for the Indian Service, and weighs 150 lbs. It, too, can be fired from either a carriage or tripod, and I am assured it has been proved effective up to 1,400 or 1,500 yards. With the present traversing arrangement, the angle of lateral spread is 6° 4′, and this may be varied from zero to the extreme angle in intervals of 2°; an improvement will, I believe, be eventually introduced, to render the automatic device capable of any desired angle of spread. As you see, there are only eight barrels instead of ten; the effect of which arrangement is not only to lighten the piece, but to allow of a more rapid and continuous fire, in consequence of the freer circulation of air and radiation of heat. The angle of depression of the muzzles is only limited by the length of the elevating screw, and the convenient manipulation of the piece in action, but there is no difficulty in obtaining a depression of 10°, the carriage standing on level ground. The cartridges used with this light gun are precisely the same as those issued for the service of ordinary 0·45 Gatlings, and they will probably be carried in India on pack animals. No special mountings have yet been designed for the gun, but any ordinary field-carriage is available for the purpose.

The weight of our service Gatling, and the width of its track, precluded its effective use in the Ashantee War. One of the guns sent out was, however, mounted on an extemporized narrow-track carriage, and, although consequently top-heavy and liable to frequent upsets, it was taken to the banks of the Prah to command the bridge in certain eventualities. In bush warfare it is said that the pellet-drift from a Gatling would be ineffectual as compared with the heavier bursting deluge of a shell, but the former has exceptional penetrative capacities which ought to count for something. During the experiments in America last year, it was proved that at 150 yards the Gatling bullet pierced six thicknesses of one-inch plank, while canister balls, from a Howitzer, penetrated three only. Now the killing and disabling effects of a projectile may be said to be proportional to its penetrating power; therefore, in view of ever-recurring "little wars" throughout our widespread colonies, the non-employment of the Gatlings sent to

sirable to adapt their locomotive and carrying power to military purposes, in combination with the latest invention in firearms.

"The Gatling gun having met with the approval of a mixed committee of officers at Shoeburyness, it may be worthy of consideration whether a light gun on this system could not be made of a weight suitable for a camel gun."—"Camel Guns," Lecture by Lieut.-Colonel Maxwell, R.A.

the Gold Coast, will not, it is evident, militate against the future use of the gun before us, as an auxiliary weapon for offensive bush and hill warfare. Major Fosbery, has pointed out, very forcibly, the utility of mitrailleurs for field operations in India, the facility of their transport, the ease with which the great factories there can turn out any quantity of suitable ammunition, and the effects on the superstitious minds of the frontier-natives of an automatic straight-shooting field-piece as opposed to smooth-bore muzzle-loading cannon and inferior muskets; the excessive numbers of an ill-armed Asiatic force would, he urges, present the very conditions of success most favourable to their employment. And, again, in isolated posts and hill forts defended in troublous times by small and perhaps sickly garrisons or in the neighbourhood of large cities infested with turbulent populations, the mere presence of a mitrailleur battery could not, he thinks, be overrated. But as regards the use of Gatlings in European warfare, what are the points to be urged in their favour? Should they be disseminated among field batteries to act as far-ranging case-guns, or should they be applied as a collection of small-arms to the intensifying of infantry fire at critical moments? In other words, ought the Gatling be served exclusively as a field-piece or as a regimental automaton? When, where, and how can they be employed to the best advantage as multiple guns? Can they be used in attack, or must they be confined to defence? Should they be invariably entrenched and masked, awaiting the opportunity that may never arise, or should they risk exposure to be efficient? These are questions that naturally occur at the outset, but which could be answered far more easily from a negative point of view; that is, it would be less difficult to show what is beyond their capabilities. That Gatlings of small-arm calibre are exceptional, in their employment, must be allowed; they are of no avail against entrenched lines nor thick cover of any sort. They possess no incendiary powers, nor can they blow up magazines or smash waggons, nor do anything that the bullet from the best rifle cannot do. The Gatling is, in short, merely a life-exterminating weapon, and should be devoted to that object. Colonel Fielding puts it in a clear, though scarcely forcible enough light when he says:—"The Gatling represents a cer-" tain number of infantry for which there is not room on the ground " suddenly placed forward at the proper moment at a decisive point to " bring a crushing fire on the enemy." Major Fosbery is, I think, more correct and explanatory in his description. "Mitrailleurs," he argues, "are essentially labour and life-saving machines, enabling a few men " to do the work of a greater number, and better than the greater " number. They will do certain infantry work better than infantry, and " certain artillery work better than the artillery themselves." There is, however, a common-sense limit to this definition as supplied by the gallant Officer himself, when he adds the proviso that they should be introduced "neither as artillery nor infantry weapons, but as a class " apart, to assist both, but interfere with neither."

The question of organization is intimately bound up with that of the proper employment of mitrailleurs. As to this, Major Fosbery expresses the hope that we will not be persuaded to man and equip our mitrailleurs

as horse-artillery batteries; but, leaving them in their intermediate place, educate a separate class of men for their service, "taking, for "instance, drivers from the cavalry and gunners from amongst infantry "marksmen." Colonel Wray's Committee deprecated, while they proposed that twelve Gatlings should form a battery, that is to say, such an aggregate was only intended by them to be brought together for purposes of administration. The battery of twelve guns would thus be capable of being broken up into any number of parts to be employed ubiquitously where most required. It was further explained by Colonel Fletcher that two or three Gatlings were looked upon as the largest number that could be brought together in any particular place. In this opinion the Committee were followed by the Swedo-Norwegian Commission on mitrailleurs, who, while proposing that a battery should consist of four pieces, add the remark:—"Doubtless two mitrailleuses "could alone strongly reinforce a position; but it would be preferable, "in a case of importance, that a whole battery should be detailed, in "order that tenure of a position might not be imperilled by the dis-"mounting of one or two of the mitrailleuses by the fire of the enemy." The Committees agree in treating mitrailleurs as defensive weapons only, but the English Committee require, in addition, that they should be invariably entrenched and kept as far as possible masked from artillery fire, while the Foreign Commission recommend that such weapons should be kept with divisional reserves, and not be attached to brigades or battalions except under special circumstances. Colonel Hamley, while pronouncing Gatlings useless for offensive operations, would, for defence, employ a proportion of one Gatling to twelve field guns "to be kept in depôts and only moved into position when the "time for using them had come." Captain Owen, R.A., in consonance with the Foreign Commission, would have four Gatlings to constitute the tactical unit; bringing two of them together, if necessary, for larger administrative purposes under a major, or four under a Lieutenant-Colonel. Captain Henry Hime, R.A., suggests the addition of two mitrailleuses to our present six gun batteries, or the equipment of one of the divisions of our field batteries with Gatlings instead of guns. He also thinks that a certain number of mitrailleurs should be equipped on the horse-artillery system to act as batteries of reserve. Finally, Lieutenant Pratt, R.A., would not form Gatlings into batteries at all, but disseminate them among batteries of artillery. Such are some of the published opinions as regards the organization of these automatic weapons; and, diverse as they seem to be, they will serve to elucidate the text I have submitted to your unbiassed consideration.

It has been remarked that machine-guns seem to require an escort more constantly than field-guns to protect them from flank and rear assaults. If this be so, why, to meet the difficulty, could not a fourth arm of service, in its strictest sense, be organized? It might, in fact, consist of a judicious combination of Gatlings with a corps of mounted riflemen such as proposed by Colonel Wood, V.C., last year in this theatre. These riflemen, a specially trained and picked force, should not only act as escort to the guns, but as instructed Gatlingeers (a term I suggest as an obvious substitute for gunners), ready, on occasion, to fill up the

casualties that may occur among the Gatling Detachment. Combine, at times, a large force of cavalry with Gatling batteries escorted by riflemen, mounted on horseback or carried on long cars as described by Colonel Wood, and it will prove to be a very compact, self-contained, mobile, and effective little army for sudden and distant enterprises. On the other hand, a proposal has been made to attach Gatling batteries exclusively to cavalry. In a memorandum to Colonel Fletcher's lecture on the "Employment of Mitrailleurs," to be found in the 16th volume of our Journal, General Shute, C.B., points out the advantages of the arrangement. The alternatives as to whether Gatlings should be attached to infantry or form a portion of the artillery service are disposed of briefly in the negative; and he goes on to fortify his argument by the consideration that, in his corps, the required farriers, drivers, reserve of horses, and, in fine, the establishment of a battery, are already to hand; whilst he thinks that cavalry Officers who have obtained certificates from the schools of musketry would be competent (as no doubt they would) to command the battery on special service. As to the utility of Gatlings in conjunction with cavalry, he enumerates the several occasions of great moment in which the latter is so dependent on the co-operation of the other arms of service, as when acting as reconnoitring patrols or patrols in pursuit; and, during a retreat, when posted as a rear guard; also when advancing along roads and lanes, the flanks being covered by dismounted men. Besides, the General finally refers to the fact that, as cavalry on the offensive manœuvre in open country this would also be adapted to the effective action of Gatlings. Batteries of horse artillery are either employed with advance and rear-guards, or with the cavalry of reserve. But as to this latter service, it is, I believe, undecided whether the guns would not be better employed in taking part in the general fighting, than by being kept back with cavalry, getting no opportunity for action. In such event, however, they would have to expose themselves within case-range to the enemy's infantry and mitrailleur fire; whereas Gatlings could manœuvre outside the range of the former; while, at the same time, producing far deadlier effects than the guns. So long ago as 1858, the prescient intellect of Sir John Burgoyne foresaw the employment of machine-guns in the field, and he recommended them strongly. He also proposed that the largest proportion of rifled field artillery should be of small calibre, and so reduced in size and weight as to be drawn on two wheels by two horses; in other words, the combination he laid such stress upon, is to be found in the Gatling gun before you.

It must be assumed that all Gatlingeers would be thoroughly conversant with the powers of their gun, for they must be prepared to take part with whatever branch of the Army is immediately in need of their services, and to carry out these duties with that arm with intelligence, care, and skill.

In the early actions of the great war, it is noticeable that the French used their mitrailleurs side by side with shell guns in the field, thereby encouraging the former to fling away ammunition at impossible ranges, and exposing them to the special attention which guns receive

in action. Instances of this fatal error might be multiplied; it will suffice to quote two or three from Captain Clarke's translation of the authentic records. Early in the day at the battle of Wörth, 84 guns of the 5th Division opened fire at from 2,400 to 4,000 paces on the French guns and mitrailleuses, when the latter, unable to reply were forced to decamp. Later in the day, when the 21st Division Artillery engaged at long range five French batteries, one of them being a mitrailleur battery, it was the latter the Prussians promptly silenced. So also at Spicheren, when Von Goben arrived, his six batteries of artillery directed their fire chiefly on the exposed but distant mitrailleurs of Laveaucoupet's artillery. To destroy mitrailleurs seemed to have been a favourite and not unnatural pastime of the overwhelming and well directed Prussian artillery; but surely this fact indicates the measure of their respect for the weapon, and is a strong argument in its favour, for, as Colonel Hamley enjoins, "guns should bear on that arm which threatens most."

In selecting a position the Commander of a Gatling battery would naturally seek temporary concealment, but to be effective he must emerge from cover, and to be safe, his shelter must not be of a nature to preclude immediate action against an assault. Before the enemy he must manœuvre within the range of artillery, but outside that of effective small-arm fire. Provided the ground in front is comparatively open, other conditions do not appear to be of moment. During the Franco-Prussian war, the best effects were produced when the mitrailleurs were posted on an eminence commanding the slopes of another and the intervening valley, or where stationed at the head of a ravine which had to be traversed by the enemy, or just within the verge of a wood on the flank of a position.

"Mitrailleurs and range-finders are imperatively demanded by "modern requirements," observes Major Brackenbury, "we have the "only good mitrailleur—the only range-finder at all; both of them "should be issued and tried at the Manœuvres." But it is not alone at the Autumn Manœuvres, but at private exercises over rough ground under every condition of attack and defence, that Gatling batteries can be prepared for the exigencies of service on occasions pronounced favourable to their effective use, bearing in mind that at distances proportionate to the size of the weapon employed (for Gatlings are of all calibres up to one-inch bore) they are capable of a more certain and continuous fire than any field gun. Among these capabilities may be enumerated the acknowledged power of the Gatling for the defence of entrenched positions and villages; for commanding roads, defiles and bridges; for covering the embarcation and disembarcation of troops, and for the protection of a column moving to its destination by railway; for silencing field batteries or batteries of position; for increasing the fire of infantry at critical moments, and finally for supporting field batteries and protecting them against cavalry or infantry charges. Lieutenant Pratt, when treating of the difficulties connected with the artillery of advance guards, adverts as follows to this latter duty of Gatling batteries: "where batteries of artillery "have to advance rapidly to the front to gain a good position it is

"evidently necessary for them to have a mounted escort; when they "have gained their position, infantry support is required. Advanced "batteries, then, require a double escort both infantry and cavalry to "be efficiently supported. By using a hybrid force, like the old dra- "goon or the mounted rifleman of the future, the difficulty is partially "obviated."

But he has a complete and instant remedy to propose: "Suppose "one of these," he subjoins after describing our service Gatling, "drawn by two horses, was attached to a battery, it would be escort "enough in itself. Where more than one battery is in position "effective cross-fire could be maintained. With two-horse waggons "for ammunition, the additional *impedimenta* to an army would be "trifling; and I think this weapon, owing to its mobility and efficient "defensive power, would be the most effectual escort to the artillery of "the future." The commander of a Gatling battery should know from habitual experience how best and most judiciously to give effect to the general directions he may receive for his guidance, but he should endeavour to keep out of fire until the moment for action is evident to his trained senses. Finally, he must, while seeking all immunity from the fire of artillery, in reality so despise it as never to be diverted from the main object of his presence on the field of battle, namely, the prompt slaughter of men and horses.

"This arm is chiefly of a defensive nature," report the Swedo-Norwegian Committee on mitrailleurs, "which, nevertheless, does not diminish its importance or merit, even in field warfare;" and, as corroborative of an assertion made earlier in this paper, they add elsewhere, "We cannot too strongly insist on the importance of not con- "founding mitrailleurs with artillery, as much on account of their effect "as the proper nature of their employment." Another point to which this Committee advert is the fact that the rapidity of fire produced by breechloading rifles has hitherto been utilized not so much in open combat as in the seizing of positions, villages, heights, edges of forests, &c., and a position attacked and taken one minute should the next be capable of defence against renewed efforts of the enemy to retake it. "However," remark the Commission, sententiously, "as "regards the United Kingdoms, this quality of the mitrailleur, that of "taking part chiefly in defence, should not be considered as a fault "but rather as a reason for its introduction amongst us." Is this not equally applicable to *our* United Kingdom? But, on the other hand, we should remember General Eardley-Wilmot's warning on this head, when he says, "If the system is to be looked upon for defence alone it "is likely there will arise difficulty in its application, as it will come "to be considered a mere reserve and will not be available at critical "moments."

As fearfully and conclusively proved in the latest contest, infantry will more than ever be employed in skirmishing order, for the breech-loader and the mitrailleur have forced close columns to deploy. Yet so lately as in the early part of 1870, Louis Besançon advised the deployment to be the primary formation of infantry at 1,200 yards and the distance not to be reduced, "except under the presence of

"superior power, so as to gain the full advantage from the Chassepôt." Had he been speaking of the mitrailleur he would in this have expressed its exact and rightful position, but of nervous, uncertain, excited riflemen, surely the idea is preposterous!

The effective sphere of infantry fire has been variously estimated as lying between 400 and 1,000 yards, but when we consider the many deterrents to good shooting, such as a moving object, smoke, fatigue, excitement, and attention to orders, the majority will be of opinion that 600 or 700 yards at the utmost is the reliable zone of accurate infantry fire action.

On the other hand, field guns, such as ours, would deal effectively with masses at ranges of from 3,000 to 4,000 yards, but they are as liable to error at short as at more extensive ranges. Hence it is Major Fosbery is of opinion that when posted in a defensive position there exists a distinct measurable space between the effective sphere of infantry fire, and the best effects of rifled field-guns which ought to be confided to the special care of machine-guns, as superior to either for the purpose. This area he fixes as lying between 600 and 1,200 yards. Thus an enemy advancing to the assault would have to pass through an organized fire action.

At the outset, shattered by the far-reaching fire of artillery with ascertained range and adjusted fuzes, as first line, second line, and reserves come successively into view, the enemy would have to pass into the zone of the mitrailleurs' fire, and finally be received by riflemen (with full pouches, strength, steadiness, and nerve, carefully reserved) within their most fatal distance. For the defence of such prepared positions, Gatlings have indeed been pronounced by the United States' Committee of last year, "superior to any species of artillery against "troops exposed to view;" and remember, too, that from its lightness the Gatling gun can be readily withdrawn from any point exposed to an overpowering or disabling fire, and be replaced in battery to meet the critical moment of assault. Of course, to be effective against field guns, the larger Gatlings would have to be employed, but even these ought never be opposed to artillery when there is more chance of being dismounted themselves than there is of preventing the service of the guns. This, however, is a moot point worthy of discussion. The Prince of Hohenlohe-Ingelfingen, himself an artillery officer, deprecates the exalted opinion of artillery fire formed by outsiders, "errors," he says, "of which artillerymen themselves are not innocent, because "proud of their arm, they are prone to ascribe higher qualities to it "than it really possesses." The French mitrailleur, composed of 25 large-bore encased barrels required the same number of men and horses as a field-gun, and yet Colonel Reilly, R.A., witnessed on one occasion one of these 6-horsed mitrailleurs standing in the open, exposed for 4½ hours to the much-vaunted fire of the Prussian artillery, unscathed and defiant. Artillery can smash the Gatling and blow up its limber, it is true, but how, if the gunners and horses be disabled during the attempt?

The course of a battle has been minutely described with reference to the action of the three arms by Prince Kraft of Hohenlohe, in his

pamphlet, as translated by Captain Clarke, R.A. Let us consider it for a moment, with this exception to the Prince's description, that we will credit both sides with acting on similar antagonistic principles up to a certain point.

In the offensive form of battle, the change from the march to the combat, occurs naturally enough. The advanced parties, whether cavalry or infantry, fall in with one another and commence the business, feeling each others pulse, as it were, and noting any indication of making a determined stand. The officers in command of the advanced guard on either side, then call for artillery, which immediately enter on a duel, occasionally sending shot or shell, at the rapidly reinforced first lines of infantry. Seeing this state of things, additional guns are ordered up on both sides, so as to delay the action for the arrival of the main body of infantry, and while the latter form up for attack, the guns are moved forward to closer quarters against that portion of the opposing line where the decisive assault is to be attempted. "If the form of the ground and the situation of the fight "are such that the chief blow must be struck in quite a different "direction to where the advance guard is engaged," says the Prince, "then the artillery of the advance guard will be charged with support-"ing the latter in the local objects of the fight, while the reserve "artillery will unite with the artillery of the main body to prepare the "principal blow." So soon as the position is sufficiently shattered and demoralization sets in, the main body of the infantry is pushed forward to close quarters, keeping up an incessant fire in conjunction with the artillery, until the latter is masked by the former and is obliged to turn its attention to some other object; to the enemy's guns or to any reserves in sight, or perhaps the great risk is run of continuing to fire shot and shell over the heads of the advancing mass, until the endangered region is reached. But here we must pause; for conjoint action is no longer possible. One party must win the day, and immediately the artillery of the conqueror moves forward to the captured position. Then cavalry and horse artillery follow up the discomfited foe and complete his ruin. Now this, I presume, is a fair exposition of the modern offensive combat, and let us see where Gatling's could be utilized during it. If cavalry move in front of an army and meet infantry, they are compelled to fall back for protection, whereas if associated with a Gatling battery, and its attendant mounted-rifleman escort, as suggested, important positions could not only be seized, but retained. If, from the closeness of the country, a body of infantry forms the advance guard, it too would frequently require the friendly aid of a Gatling battery to strengthen its fire at critical points, and in either case two or more Gatlings would prove efficient auxiliaries to the field batteries usually so employed, on the acknowledged principle that with advanced guards the most reliable gun is that which is most effective against troops and which can carry most ammunition; for it has to go into action first and remain there longest.

But then as the action develops into a serious general encounter, a further call for artillery is customary, and a duel is entered on, which,

according to the Prince, must be carried on within 2,000 yards, "with "any prospect of success," so that, if we employed such weapons, Gatlings of the larger size might then take part in the combat and be found useful to divert, disconcert and even silence the opposing field batteries. But by this time, as we have seen, the infantry have become engaged, and while the rapidly-reinforced first lines press forward, might not the Commander of a Gatling battery find a nook for the service of his guns on the flank of the supports nearest to the selected point of attack, ready to intensify their fire, and that of the main body when it arrives? or, if this would not be feasible, might not the Gatlings, at a later stage of the fight, and while the deployed battalions of the main body are marching forward to the assault, be moved into a position, however exposed, so as to continue their concentrated fire-action to the latest possible moment of final contact, the chief aim of tactics being to obtain the utmost development of accurate fire as the surest way of breaking down the enemy.

Again, it not unfrequently happens that the first assault of a position fails, or the enemy has only made a pretence of maintaining the defensive so as to put an end to attack by a vigorous counterstroke; confusion and perhaps retirement follow. This, then, would be the opportunity for a well-posted Gatling battery, and its timely aid might turn defeat into victory, for a sudden and well-sustained cannonade from an unexpected quarter will often change the fate of an engagement. Finally in the pursuit of the demoralised foe the Gatling battery might, in conjunction with horse artillery, convert the retreat into a complete rout. There is another phase of the offensive combat which seems to offer facilities for the action of Gatling batteries, namely, turning movements. "It seems not unreasonable to infer," observes Lieutenant Maurice, R.A., "that the whole defence will collapse as soon as small "bodies of assailants appear on the extreme flank." Thus it is likely that the General will profit by the mobility of Gatlings superior to that of field-guns to assist in such outflanking manœuvres. It is, therefore, in the spirit of the foregoing considerations that I venture to ask, would not Gatlings, under exceptional circumstances, contribute very powerfully to offensive tactics? Inseparably connected with the employment of Gatlings in the open, must ever be kept in view the conjoint use of tools for extemporising cover. In the Russian Service a few fascines are, I believe, carried on the limber, which may be readily arranged to mask the gun. If a wall or building be available, the Gatling can be worked from behind a loop-hole, and thus a few men would be enabled to keep a host at bay. In close country, such as surrounds the metropolis, interspersed with villages, parks, farm buildings, &c., there would be numberless opportunities for the right employment of Gatlings in this manner. In siege operations it is admitted that both for besiegers and the besieged, machine guns are most useful auxiliaries. During the siege of Metz, some Landwehr regiments were stationed in defence of the intervening villages of Ladonchamps and Tapes, against whom a sortie was made by the French. When the assault began, part of the 10th Army Corps was directed to advance to the relief of their comrades, which they did in

skirmishing order, and in columns of companies. "But," says the correspondent of the *Daily News*, from whom I quote, "the mitrailleur "venomously sounded its angry whirr, making the skirmishers recoil "nervously as they crossed the line of fire, and leaving chasms in the "front of the solid masses of which they were the forerunners." The French columns were, however, ultimately driven back. As usual, neither mitrailleur nor chassepôt (although they used the former "with rare judgment and effect") were of long avail against the overwhelming hosts of stern and stubborn Prussians. And herein lies the moral that Gatlings, however invaluable on occasion, must at all times be backed by a stalwart soldiery, reliable and invincible. The true strength of a nation is its manhood.

There is one other obvious opportunity for the right use of this weapon in the field to which I must allude in conclusion. To repel night attacks on camps or bivouacs, the Gatling gun is thoroughly reliable. A practical instance of its good service in this respect is related by the same authority from whom I previously quoted. During the Khivan Campaign, the column to which the Gatlings was attached moved forward on one occasion, leaving all its baggage packed in charge of a small detachment provided with the two Gatlings. At nightfall it was ascertained that the enemy lurked in large numbers in the vicinity of the camp, and accordingly the Officer in command took every precaution to prevent surprise. The baggage-waggons were collected into a square, and in a corner formed by the front and right sides he placed the Gatlings. At 3 o'clock in the morning the attack of the Turcomans commenced. "At the first howls of the "enemy," he says, "I hastened to form a cover for my guns. I put "on the right wing 10 privates, on the left 15 sharpshooters, and 12 "men of my battery guns command, with whom I could dispense for "the present. These men were also armed with rifles. Leaving thus "with the battery guns only the most indispensable men to assist in "firing, I took myself the crank-handle of the first gun, and invited "Captain Cachourin to take the handle of the other gun, and enjoined "on all my group not to commence the fire before the word of com-"mand was given. The guns formed an obtuse angle with one another, "as it was necessary to direct them to the precise spot where the "shoutings of the enemy were heard, and whence they were approach-"ing us. We had not long to wait. The cries of the Turcomans who "had succeeded in breaking through the lines of our detachment and "turning their flanks, suddenly rose from all sides, and became deafen-"ing. Though it was dark we perceived in front of us the galloping "masses of the enemy with uplifted glittering swords. When they "approached us within about twenty paces, I shouted the command "'fire.' This was followed by a salvo of all the men forming the "cover, and a continuous simultaneous rattle of the two battery guns. "In this roar the cries of the enemy at once became weak, and then "ceased altogether, vanishing as rapidly as they rose. The firing at "once stopped, and as no enemy was visible, I ventured to get a look "at the surrounding ground, availing myself of the first light of dawn. "At some distance to the right of our square stood the 8th Battalion

"of the line. Between it and us, at every step, lay prostrated the dead "bodies of the Yonoods, their hats being pushed up to their eyes. "*I saw no wounded.* They were probably all carried away according "to the usual Turcoman warfare." This is a significant and terrible, because simple account of facts, and fully bears out the destructive character of the gun. Mark, too, the immediate moral effect produced by this automatic manslayer. Its very snarl hushed the war-cries of the savage foe. It caused the Yonoods to reel in the saddle and wheel their fiery steeds back once more into the desert; all, that is, who did not bite the dust. I cannot fancy that they returned for wounded men, I cannot fancy that there were any to take away.

Surely, then, it may be conceded that Gatlings have a just claim on the attention of tacticians, and that the sooner its place be authoritatively assigned, the sooner will our men be skilled in its inevitable uses; for no foreign Army will in future take the field unprovided with a complement of machine-guns, and we must be prepared to meet them with at least equal weapons and superior tactics.

The days of obtaining any number of mercenaries to supplement our little Army, in case of European complications, have passed away. Nations are too jealous of their wants to overlook the exodus of any portion of their recruit-giving population. How then are we to fill the gaps created by the primary actions of a campaign; and how in future can we most promptly and economically prepare to resist invasion at home, while our ever-victorious Army is obtaining satisfaction for us abroad? Said the *Times* lately, "Conscription "in any country and in any form is the most cruel of all taxes, be-"cause it is a forcible interference with the natural course of existence. "If it can be avoided, any system is cheap which avoids it." Well, Sir, one object of my presence here to-night is to proclaim part of a system which shall meet the difficulty. Both the English and American Committees declared one Gatling to be equal on occasion to a company of average marksmen, that is, that two batteries of Gatlings, well served, are as effective as an entire battalion of infantry.[1] Is not the reasoning sound? it is at all events an *argumentum ad hominem*, for it dispenses, in a great measure, with his presence. We are burthened with an extensive coast line both at home and abroad, and for the defence of its integrity, Gatlings are, as an auxiliary arm, preeminently fitted. But is this all they are capable of—can they take no special part in active hostilities in the field?

We have, as you may see in the specimen before you, a light and perfect weapon of its kind, and which might well be issued for service in Europe as well as in India. Formed into batteries of six guns each, in the proportion of one battery of Gatlings to a brigade of artillery, and provided, in addition to their limbers, with two ammunition carts per battery, carrying in all an average of 4,000 rounds per gun, these guns, if placed not alone with the general reserves of an

[1] "Reckoned simply by the number of hits in the target, one 0·42-inch calibre Gatling, using the oscillator, is equal to 70 Springfield rifles firing against time, and 52 rifles firing deliberately. Without the oscillator, every shot from the Gatling should strike the target."—Extract from Report of United States' Committee, 1874.

Army, but on occasion with the artillery of the advance guard, or with a cavalry brigade to act in conjunction with horse artillery, would be available for service, at all events against cavalry and infantry within a range of 1,200 yards, and for critical opportunities at all times. "Many cases must arise in war," says Colonel Hamley, "in which the "long range of the field-gun would be superfluous, while the mitrail-"leuse could be employed under its own conditions of effectiveness. "In all countries not absolutely flat, troops may often engage with no "greater distance than 1,200 yards between the hostile forces."

There is yet another mode of utilizing to the utmost the powers of the Gatling gun. I have before now proposed that some regiments of our artillery auxiliary forces should be trained to their use for interior field operations, as well as for coast defence; and I venture on this occasion to renew the suggestion, not because I think Gatlings are weapons simple in manipulation, for they are not so; nor yet because they are likely to afford moral and material support (which is stated to have been the motive of the Austro-Hungarian Government for supplying mitrailleurs to their regiments of militia), but because Gatlings require the utmost intelligence, the most skilful handling, the readiest resource, the highest courage, and the best tactical genius that can be drawn to their service.

In much of what I have put forward in this paper, I have advisedly taken the unpopular, and according to the majority, the impracticable view of the mitrailleur question, inasmuch as I have suggested a claim for the Gatling to occupy a place in the preliminary phases of a battle. I do so, I can assure you, in no captious spirit, nor unmindful of the fact that any departure from defensive operations has been pronounced outside the province and mission of machine-guns, but perhaps you will think it only fair to discuss the doubtful as well as the certain contingencies affecting the possible status of Gatlings. No doubt each arm of service deems itself the exponent of the nation's prowess, and each in turn will claim the foremost place in the brunt of battle. It is a generous rivalry, a wholesome competition; but may it not be pushed too far, for in this contention it is likely that so valuable an auxiliary as the Gatling will be overlooked by each and all?

Distribute Gatlings permanently among divisional field batteries, and they will often be committed to engagements at ranges beyond their powers, and their very existence may be forgotten on occasions most favourable to their small-arm rifle character. Attach Gatlings exclusively to cavalry and they will sink into an inferior class of horse-artillery, again losing distinctive characteristics. Finally, post Gatlings in fractional sections to infantry, and, in addition, to difficulties of organization and administration, they will become a stumbling-block and perhaps a snare, for they may come to be regarded either too dependently or not at all. Depend upon it, if an hermaphrodite position be assigned to these weapons—if the pieces be dispersed capriciously as described, the Gatling will become not an auxiliary-arm but the scape-goat of the services. On the other hand, if distinct organization and latitude of action be allowed to them, so also, as I have endeavoured to point out, should the military education and tactical training of

Gatlingeers reach the highest possible mark. Yet even then it is to be feared that this application of the science of tactics, however varied and habitual, will fall far short of that practical experience and indefinable mastery of situations as they arise, only to be gained amid the smoke and carnage of the battle-field.

The CHAIRMAN: We have all listened, with great interest, to Captain Rogers' paper on the Gatling gun, and I would invite gentlemen who may feel disposed, to make any remarks that may suggest themselves to them upon the subject. I would specially call attention to the concluding observations of the lecture. Captain Rogers wishes it to be understood that he has advanced no special theory, but has stated the subject fairly, in an unprejudiced way, and is particularly anxious to invite criticisms and discussion on the matter.

Captain J. F. OWEN, R.A.: I am sure we all owe Captain Rogers very much for bringing this subject so clearly before us. He has collected the very latest facts which bear upon the Gatling gun, and, however we may differ from him in his mode of applying these weapons in the field, we all, I am certain, shall agree in one thing, that, if they are to be employed, it would be advisable to settle what organization should be used with them, as soon as possible. It seems to me that Captain Rogers has somewhat exaggerated the importance of this weapon, as to field warfare. We are here to-night to discuss the tactical use of Gatlings in the field, and not the use of machine guns in fortifications, or on board ship. With respect to that, I think there can be no difference of opinion. With respect to fortifications, for instance, the space in front of these guns, or any other ordnance that you have, is already cleared; but, in the field, we must remember that the least obstacle in the way renders such guns perfectly useless. It is not often that you have in the field a space prepared for the fire of a machine gun, as you have on the glacis of a fort or on a smooth beach, where you have to fire against troops who are trying to prevent a landing from boats. In such cases, the advantage of Gatlings is enormous. These weapons have little or no recoil, so that, both in boats and caponniers, where the space is restricted, the importance of their employment can hardly be exaggerated, though merely as a supplement to the heavier ordnance. In the field, however, the case is very different, and the question is, whether the disadvantages do not more than counterbalance the advantages of taking any number of Gatlings with an Army in the field? In a battle, for instance, it would be a great advantage to the artillery to have a very heavy gun to reach the enemy's reserves, and to silence his field guns at great distances, but we know we cannot take heavy guns of that description into the field, the impedimenta are too great. The question for us seems to be, are the advantages of the Gatling such as to counterbalance the disadvantage of taking extra impedimenta into the field? Their range is very limited; between 650 and 1,000 yards, Captain Rogers lays down as the distance where their fire would be effective. That is a very small space. Beyond that they would be of little or no use, while artillery is not only formidable beyond 1,000 yards, but even within that range its case-fire would be very effective. Still, no doubt, as a supplemental arm to the artillery, the Gatling would have its uses, but I think we should limit its numbers. As to organization. Captain Rogers suggested a very anomalous sort of organization, the absolute establishment of a fourth arm, as far as I understood. I do not think, as a rule, we could agree to establishing a fourth arm, when we have an arm ready to receive such a weapon. It is, in fact, merely a light field-gun, and, in that way it is employed by those powers who use it on a large scale. The French have so used it, the Russians, in their organization, have one battery armed with mitrailleurs in each artillery brigade, and so they have in Spain. One or two other points I should like to allude to, for instance, as to the tactical use of this weapon in the field. Captain Rogers proposes that guns should be protected by mitrailleurs, on their flanks. Surely, we can scarcely feel that a battery of artillery would be safely guarded by a Gatling on each flank. It is very rarely that the space in front is fitted for the employment of such weapons; unless the country is carefully prepared beforehand, it would not answer. Then, how about the enemy's skirmishers creeping round the flanks, under cover? The Gatling would be useless

against them, whereas, if you are protected by an infantry escort, the infantry could throw out skirmishers to meet the enemy. In the Franco-Prussian war, batteries of mitrailleurs were, on several occasions, captured by the enemy's skirmishers reaching round their flanks. If they are not able to protect themselves, they would not be able to protect a battery of artillery. That is quite clear. I cannot agree in the advisibility of so employing mitrailleurs. There is still another point I should wish to allude to, viz., the training of the men who are to use these weapons. They should undoubtedly have a special training; and anybody who has examined the mechanism of those pieces will agree with me that it requires skilled men to work them. In whatever way, then, we treat Gatling guns, they should not be placed in the hands of men who are not specially trained for their use, and the reasons are all the stronger for special organization, and for not mixing them up with either infantry or cavalry.

The CHAIRMAN: I would draw attention to the fact that Captain Rogers has denominated his paper, "The Gatling Gun; its Place in Tactics." I think this title includes naval as well as military tactics and I notice, in one or two places in the paper, that he has alluded to the use made of the Gatling in naval warfare as well as in the field; therefore, if any gentlemen will favour us with remarks in regard to naval operations connected with the gun, we should be glad to have the benefit of their views on the subject.

Major HALE, R.E.: There is one question I should like to ask the artillery Officers here present—whether they consider the Gatling gun, at short ranges, superior to their own field-gun? In my humble opinion, it seems out of the question to use the Gatling at ranges beyond effective infantry fire, because, directly the Gatling gun opens on the distant infantry, the enemy's field-pieces could open on your Gatling gun; therefore, the Gatling must be kept under cover until the very last moment. The last speaker talked of it as a field-gun. I look upon it as ten nerveless infantry soldiers. The Gatling gun should be used where the enemy's artillery can no longer attempt to silence it, when the enemy's infantry have got so close to your position as absolutely to mask their own fire, at that point when your own men's nerves begin to fail; that would be in the defence of a position within case-range. Of course, if the artillery think their case-fire, or can prove that their case-fire, is superior to the Gatling, then, by all means, let them use their guns instead of the Gatling; but if the Gatling is superior to the artillery field-piece at close range, then, in defence positions, the Gatling surely should be used. Artillery Officers are particularly anxious to impress upon us that the Gatling is of invaluable service in caponniers, or the defence of ditches. There they quite admit it is far superior even to ordinary field artillery. Whenever a battle is fought, one side is always on the defensive. At some period of the engagement, the enemy are coming quite as close to the defensive side as ever they would be in a ditch of a fortress; therefore, out of their own mouth, do I condemn artillery Officers, and say that there are certain cases on a field of battle on which the Gatling is superior to their own field-piece. Then comes the question, who is to make use of the Galting gun? The artillery like it and do not like it. They think they must take it, and yet they do not quite like to take it. The cavalry, they have nibbled at it, but I think most of us are of opinion that it is hardly a cavalry weapon. The infantry, I do not think they very much care about it, for the great feature of infantry is mobility. I ask, whether such a weapon will make a battalion particularly mobile in the field? The lecturer has recommended the formation of a fourth arm of the service to take charge of the Gatlings, but there is already a fourth arm of the service, called the engineers, and, if nobody else will take the Gatlings, why not try whether they can take charge of them, rather than let the weapons be lost for want of some one to father them. The engineers are specially defensive; they have got a train already; it is their duty, directly a position is taken up, to occupy a village or the strong points in the position. Why not give a couple of Gatlings to the engineer train? Why not, when a company of sappers or a German pioneer company is thrown into a village for defence, or are told to occupy a wood, why not let them have their couple of Gatlings by them, and put them under cover, in the best possible positions for defence?

General Sir ROBERT PERCY DOUGLAS, Bart.: I think a very important question

is raised by the last speaker, and I should be very glad to hear some military Officer answer it, because in the first part of this paper we heard words, such as "super-"cession of artillery," and "snuffing out artillery." I was glad afterwards to hear the lecturer say, that this was not to supersede the artillery, but was to be an auxiliary arm. I think it would be very valuable if some artillery Officer would reply to the question put by the last speaker, whether the Gatling would in certain ranges, limited say to between 600 and 900 yards, be as efficient or more efficient than their own case?

Captain OWEN: I feel that I am trespassing very much upon this meeting in getting up a second time, but I do not see any other artillery Officer here who is prepared to do so. Of course we all admit there are occasions on which the weapon before us, may be of great importance. No artillery Officer would deny that there is a certain range, say from 600 to 1,000 yards, in which Gatling guns are very formidable; but the question is—whether their disadvantages do not more than counterbalance those advantages when you consider that the larger an army is, the more difficult becomes the task of the General as to its impedimenta. We can only take a certain number of wheeled carriages into the field. Is it advisable that as many as possible should be field artillery, capable of engaging at any range up to 3,000 yards, or only such weapons as we see here with so limited a range as to be only useful between 600 and 1,000 yards? If we could carry both, no doubt we might do it advantageously, but we are tied down. The question I repeat is, how many pieces of ordnance can we take with advantage into the field? If we could take these guns, and take field-guns and heavy guns as well, and employ them all three, so much the better, but we can only take a certain amount. As to the employment of the Gatling with the engineer corps, of course that is not for me to talk about. It is not, I think, the usual idea that sappers and miners should have a gun of any sort, but I can venture no opinion upon that point. Caponnieres have been referred to, and we are told, because an artillery Officer says that a mitrailleur is a most excellent weapon in a caponniere, therefore he blows hot and cold when he says, that he does not consider it can be used in the field, except in very limited numbers. I think that is a total misapprehension, because in the fortifications, where caponnieres occur to protect a flank or ditch, the fire is necessarily limited to a certain range, the very range at which these pieces are so useful, say between 600 and 1,000 yards. A field-gun in such a position would be thrown away. Being only able to fire up to a certain range, what would be the use of having a piece which could fire further; therefore, I say, in a position where you cannot gain any advantage by the longer ranges of a field-gun, it is well to use a lighter weapon of the nature of the Gatling. The absence of recoil also makes it valuable for such uses where your space is confined, though it is a matter of small importance in the field where you have plenty of room. That is one of the reasons why, if I may again say so, artillery Officers are not inconsistent where they do not think it advisable to take a large number of Gatlings into the field, and yet say, that in certain posts for defence they may be of the utmost value, and that undoubtedly in the caponnieres and flanks of some fortresses, and also on board boats, where space is limited and recoil of importance, these weapons may be be very useful.

Major HALE: Will you tell us, whether they are more effective at case-range than ordinary case?

Captain NOLAN, R.A., M.P.: I saw most of the Gatling experiments at Shoeburyness, and I do not think artillery Officers claim very much for case beyond 130 and 200 yards. I should be sorry to say it is more destructive than one of those Gatlings, but it is destructive up to 130 yards. We, in the artillery, have now lessened the powder-charge that drives the projectile, and when we come to use case, just as firing shot of a fowling-piece at birds, we drive the canister with less force than formerly, so at the present moment the decisive effect of our case has actually fallen off from three to six hundred yards (the range of the old Peninsular case), down to 130. Certainly the Gatlings had quite the advantage over artillery at Shoeburyness between that and 600 yards, and also up to 1,200 yards, but not to such an extent; after that they began to fall off. There are other questions raised. People seem to fancy the artillery must have some special objection to the Gatling because they do not adopt it at once, but the difficulty is this,—supposing you take half

Gatlings and half guns into the field, what would be the position of the artillery with half Gatlings and half guns? If, on one side, there were 200 guns, and on the other side, only 100 guns, the 200 guns would destroy the 100 guns in about twenty minutes, consequently, any artillery would be very slow to have even twenty guns less than its opponents, if it could be possibly helped, and it would be very difficult to bring the Gatling into the field without displacing artillery. That is the real objection of artillery Officers. It is not that they claim that the guns are more destructive to cavalry or infantry than Gatlings, but because they are of very little use in an artillery duel, and an artillery duel will generally precede every engagement; to have the Gatlings, they must sacrifice the same number of guns, and a few guns, more or less, make all the difference in an artillery duel, where the preponderance goes on in increasing ratio every moment, as some of the pieces of the weaker artillery become silenced. As to the engineers taking over the Gatlings, of course the engineers are quite clever enough to manage Gatlings, and if they choose to take up Gatlings, and to look after the horses, and go to the stables, and everything of that kind, they would no doubt become excellent Gatlingeers—I should fancy they would become excellent gunners, but perhaps they would cease to be engineers. One of the gentlemen who spoke called them pioneers, and he objected to infantry losing mobility as they would do if they had the Gatlings. Now men who are pioneers are supposed to go before the infantry, and consequently, I fancy they would lose their mobility in a still greater degree. There is no doubt if engineers had the Gatling, they might beat the artillery in the long run, but I think in doing so they would cease to be engineers, and would become gunners.

Major HALE: I used the word "pioneer companies," not "pioneers."

Admiral Sir HENRY CODRINGTON, K.C.B.: You put a question, Sir, relating to the Navy. It is difficult to see how this weapon can apply very much to the Navy, that is to say, in a way sufficiently important to make it desirable to have Gatlings on board. The style of fighting our successors will have to go through is decidedly not one in which that sort of instrument would come into play. We are supposed to be fighting now in very thick armour, and not to show ourselves outside that armour. Our dangers are, as our powers are, ramming, or perforating with very large heavy missiles; and that is the only means apparently by which we can act or be acted on, one ship upon another. I do not see, therefore, how an instrument of this sort, however well managed, can be made available in seagoing warfare. Then comes the question, how far it is available in connection with the shore? That is partly a soldier's question. I can perfectly see that putting it into a boat would give that boat the power of very large musketry fire, and so far would help a landing; but I cannot help thinking that one Gatling on the beach would be much more likely to prevent a landing on that beach than one Gatling in a boat would facilitate that landing. I do not therefore see that there is yet very much to be gained in the naval service by having this new arm. I do not know that we want it yet. When we want it we shall ask for it, and perhaps may get it, but I do not see the want of it yet.

The CHAIRMAN: There is one point Captain Rogers alluded to, namely, the use of the Gatling arm in warfare against savage tribes, or any desultory warfare. He drew attention to the operations of the Russian army against the Turcomans. I do not know whether any gentleman would wish to make any remarks upon that portion of the subject.

Captain BURGESS: Captain Tulloch, of the Royal Military College, who is unable to be present, has sent in the following note on the Gatling gun. He says, "The "Gatling gun is peculiarly adapted for the use of volunteers on account of the "expense of horsing field batteries, and the amount of drill required before "volunteers can efficiently man them. The Gatling is well suited for defensive "positions, such as would be held by volunteers in the event of invasion. At that "time the Royal Artillery would be required elsewhere."

Sir PERCY DOUGLAS: On the question of the use of the Gatling gun and its applicability to warfare against uncivilized people, from my experience at the Cape, I can say it would be very valuable. I have no doubt one gun of that sort, with a very few men, would hold a post against any number of natives. It would have this disadvantage, that it makes such a horrible row in going off that it would frighten

the foe away; whereas, you want them to stand, so as to get hold of them. It would no doubt strike great terror into these people. The only thing I am afraid of is that none of them would stop. For the defence of small outposts, no doubt it would be most valuable. I would also allude to the facility of transport through a country which artillery cannot well traverse. In such cases these guns would be found very useful.

Captain ROGERS: I have very little to say in reply to the remarks that have been made on this occasion. I am greatly indebted to those gentlemen who have taken part in the discussion; and, so far as I have heard, I think the observations brought forward on the subject have been supported more or less by the Officers who have spoken. Captain Owen remarked upon my not saying anything as to the use of Gatlings in fortifications. It was simply because it was a foregone conclusion. His own book takes it as a foregone conclusion that they are of the greatest use in fortifications and for repelling sorties, and so forth. He said, also, that they would afford no protection to guns because of their liability to be attacked by skirmishers. On that point I simply quoted an artillery Officer, Lieutenant Pratt, who thinks that a Gatling gun attached to a battery of artillery would be very useful for driving off skirmishers on the flanks. Of course they must be supported also by infantry or cavalry; and, besides, he mentions that hybrid force, the mounted riflemen of the future. That is a phase of the question that had better not perhaps be brought forward yet, because it is still in the future. Sir Percy Douglas misunderstood what I said about snuffing out artillery. I merely quoted from the official account of the Battle of Gravelotte, where mitrailleurs knocked over so many horses and men that the battery of artillery had to retire.

Sir PERCY DOUGLAS: I misunderstood you: I thought you were making a general application.

Captain ROGERS: I think the other remarks were generally in support of what I brought forward; and, at this late hour, they need not be adverted to.

The CHAIRMAN: I may be allowed to express the feelings of the meeting in returning our best thanks to Captain Rogers for the trouble he has taken in bringing the subject before us. I think the conclusion appears to be very much the same as that at which the Committee on the Gatling gun arrived, namely, that it is inadvisable to reduce the number of artillery; that although fully recognizing the difficulty of increasing the impedimenta of an Army by adding further wheeled transport to that which already accompanies the Army, yet that there is still a place for Gatlings in modern warfare. Of course it is a most difficult matter to ascertain what that place is, or how they had best be used; but the opinion of the Committee certainly was that there were certain positions where Gatlings were useful, and they recommended that a small number of them should be attached to an Army in the field. The whole question with regard to artillery is a most important question at the present time. Only a short time ago I had an opportunity of having a long conversation with General Sheridan of the American Army, who had had great experience in every arm of the service in the late American War, and who supplemented his experience by being a spectator of the late Franco-German War with the German Army. His opinion was, that it would be necessary to reduce the wheeled transport of an Army, and still further to reduce the artillery. He advocated an increase of mounted riflemen. I merely instance this as showing the condition of things with regard to the several arms of the service, that not only with reference to Gatlings, but also the other arms of the service, there are still many doubts as to what proportion they should bear in armies of the future. I trust we may conclude this meeting by expressing our thanks to Captain Rogers for his valuable lecture.

APPENDIX.

It has been thought advisable, and perhaps interesting, to subjoin a short description of the Gatling gun and its working.

The model Gatling exhibited at the meeting consists of eight (usually there are ten) simple breech-loading rifled barrels revolving round a central shaft as a common axis. Each barrel is loaded and fired, and the empty cartridge ejected automatically

once during the continuous revolution of the system. There are as many locks as barrels, and the cam (which is a principal feature in the interior mechanism) causes a reciprocal motion of the locks, whereby each in turn moves forward in the act of revolving, and performs the functions not only of an ordinary lock, but also of breech-plug and extractor; thus four locks are in different stages of discharging the cartridges, and four of withdrawing the empty cases during each revolution.

The working of the gun is as follows:—One man pivots a charged drum (as this cylinder is called) on the pintle above the hopper, while another turns the crank-handle. The bottom of the drum is unkeyed, and the cartridges of one division (the drum being divided into 16 perpendicular columns holding 15 rounds each, or 20 rounds as in the American gun) drop successively into the grooves of a carrier-block in front of the chambers of their respective barrels, upon which they are, as it were, seized and acted upon by the locks as described, that is, driven forward into the barrels, discharged, and withdrawn instantaneously.

The drum is revolved by hand (in the Russian service it can, I believe, be revolved mechanically) until the 16 divisions are exhausted. Straight feed-cases are used with the American 0·45 Gatling (see Fig. 2), and with the Russian field Gatling in preference to the drum. These feed-cases, which are recommended for all calibres on account of their facility for packing and transport, contain 40 cartridges. Either drum or feed-case can be promptly withdrawn and another loaded one substituted without interrupting the revolution of the barrels, locks, &c., and therefore the intensity of fire is merely dependent on the activity of No. 2 in manipulating the drum or feed-case; a rapidity of from 350 to 480 rounds a minute has been easily attained, and, as I have been informed by General Gorloff, the Russian Gatling is capable of discharging as many as 600 or 700 rounds a minute; but it is of course the capability of firing at this rate occasionally, that should be considered, rather than the fact that so many bullets can be poured forth in a continuous stream within a given time. The normal rate of firing should rarely exceed 240 rounds a minute, particularly if the front be a narrow one or if the object aimed at be a compact mass. The locks are interchangeable; and, should any get out of order, they can be withdrawn and others inserted in their places through an orifice in the cascable plate within a few minutes, but the absence of one or more locks does not affect the working of the gun, as for each lock removed, one unexploded cartridge merely drops to the ground or into a bag affixed for the purpose.

The automatic traversing apparatus (which I was unable to exhibit owing to the absence of a field-carriage and the extemporized platform not admitting of the fixture being adjusted) is simply a cylinder slipped over the crank-axle having a cam-groove on its periphery into which a circular pin enters, this latter being attached by an arm to the elevating screw. When the crank is turned, the cam-groove travels to and fro on the pin, swinging the gun with it, and thus a dispersion of fire of twenty feet in 100 yards is obtained if necessary, but this lateral spread can be reduced as before described.

One word more. I was asked how, if there were danger of the gun falling into the enemy's possession temporarily, would it most readily be put out of gear, as the drum would be too heavy an article to run away with (its weight, when loaded, is, in fact, 50 lbs.); and I suggested to hammer the pintle on one side, which would have the same effect as spiking a gun; but, obviously, the readiest mode would be to remove the crank handle.

April 27, 1875. E. R.

P.S.—While the foregoing has been passing through the press, notice of a new American Torpedo vessel has appeared, in the armament of which the Gatling gun forms a prominent feature. This vessel is called "The Alarm," and carries one 20-inch gun in the bow, and when fully equipped she will have four Gatlings on board. We have, as yet, but few Gatlings in our naval service, which, as mentioned in the text, are placed in the "tops" of ships of the "Monarch" class, while a few lighter Gatlings will be mounted for boat service in the bows of cutters.—E. ROGERS.

Evening Meeting.

Monday, April 26th, 1875.

His Grace the DUKE OF SOMERSET, K.G., in the Chair.

NAMES OF MEMBERS who joined the Institution between the 20th and 26th April, 1875.

ANNUAL.

Whyte, William H., Capt. R.N.
Walker, G. F., Lt.-Colonel 12th Regt.
Johnson, E. B., C.B., Major-General R.A.
Hayward, J. F. Curtis, Capt. 25th Regiment.

NAVAL GREAT GUNS AND GUNNERY.

By John Scott Russell, Esq., F.R.S., &c., &c.

I consider it a great honour that this Society, consisting of distinguished soldiers and sailors, has asked me to lay before them my views on Naval Guns and Gunnery. I sincerely sympathise with your professions, in the changes, not to say revolutions, you have been obliged to make in the weighty matters of your professions. I have already had to go through the same severe ordeal in my own profession. The principles which I was taught in my youth, and the practice in which I was trained in my earlier professional life, have all become obsolete, and a ship of modern times has scarcely any resemblance to a ship of past days. Within the last twenty-five years, I have had to abandon all the older constructions, both of ships for merchant service and ships for war, and have had to unlearn nearly all my old prejudices, and to invent or to apply entirely new principles.

You are now being obliged to suffer the same change in guns and gunnery, that I have undergone in ships and their equipment. My experience in guns has been chiefly in naval guns. I had formed a very high opinion of our old naval guns; the long 32-pounder, the 65-cwt. 8-inch gun, and the 95-cwt. gun, were especial favourites of mine, especially the 65-cwt. 8-inch gun. In all the war vessels I have built in which the choice of armament fell to my duty, I adopted the 65-cwt. 8-inch gun as that out of which I got most useful work. For exceptional long range I used the 95-cwt. gun of 8 inches calibre. In my opinion, these were perfect guns of their size and of their time.

What I propose to lay before you to-night is the special question, What should be our new naval gun, to take the place of my favourite old 8-inch guns? Now the choice of the right gun for your use lies with you, not with me. You know what you want the gun to do; you know what size and weight of gun you can manage. All I will presume to do is to lay before you the advantages and disadvantages which belong to one kind of gun, and not to another nature of gun.

The two important points I first want you to settle this evening are

these, What weight of gun can you accept as the manageable weight of gun? Next, What work do you want the gun and its projectile to do? If you settle these two leading points, I think I can see how all the rest can be done.

First then, according to your knowledge and experience, what weight of gun can you handle at sea with the aid of the best modern gun carriage?

From all I have been able to learn of experienced practical opinion on this point, you can easily go to 12 tons weight for the naval gun. Twelve tons is a great weight; but with the system of modern pivoting and modern carriages, it is, I think, quite practicable. If you take 12 tons as your limiting weight, I will accept it as a settled quantity, and enter on the important questions which follow: What shall be the bore of this gun? its thickness, its length, its charge, its shot, its work come later.

Now the choice of bore is of radical importance. We have in our service—and other nations have tried—every bore of gun from 8 to 12 inches, with every variety of weight from 6 tons to nearly 40 tons. I think I express your own opinions when I say that it is not at all clear that any one of these is a gun which you are content to accept as the naval gun of the future English Fleet.

I will, therefore, now ask you to consider this one question of a gun of 12 tons weight of metal, and settle whether you will accept for it a small bore or a large bore. As small bore, let me say $8\frac{1}{2}$ inches; as large bore, let me say 12 inches. Our question is, whether for our naval purposes the smaller or the larger is the better?

When I ask the reason why greater progress is not made in naval artillery, and greater progress is not made in some points which I think are improveable, namely in the construction of ships of war, I am continually told by our legislators and authorities, that the one reason they do not get on faster with naval guns and with the construction of ships is, "that the sailors whose business it is, do not "know their own minds and have never made up their own opinions, "and if you ask them, they can neither tell you what sort of ship they "want, what they want it to do, what sort of guns they want it to "carry, or what they want to do with their guns." They say that—I know it is not all true; I know you have each made up your own mind thoroughly upon these points, but I am afraid there is some truth in the observation that you do not quite agree. I hope you will not think me foolish and sanguine if I hope that either this evening, or if we cannot make up our minds this evening, perhaps at a meeting to-morrow evening, we should together make up our minds and say we are of one mind, "we want this gun, for *the naval gun* and no "other." I say to you, if you will settle what you want and agree in it, I am quite sure I know clever fellows enough in England, clever builders enough, able enough contractors in England to undertake that if you say what you want "you shall have it." Excuse my interpolating this observation, but I do so to say that I come here this evening with an earnest hope that you will after an ample discussion settle absolutely what it is the profession wants.

Now before choosing, it is well to draw a line of some importance, between guns to be used by soldiers on land, and guns for naval service at sea? The difference in conditions is this, that guns on land have a steady platform; on sea they have a moving, heaving platform. This distinction is most important for our purpose. Suppose a gun being built expressly for a fixed land battery, say for the defence of Dover, or Portsmouth, or some other harbour; extreme long range of gun might be of great exceptional value in such a case, and worth a large sacrifice. One gun of 5 miles range might be worth 10 guns of 3 miles range; but on board ship, as a rule, the man who would fight his battles at so great a distance, would not be wise, for he would certainly waste his fire. If I understand sailors aright, what they want is, guns that will fire quick, with great destroying power of shot, so as to pierce the enemy, damage, and sink him within a moderate range and with least waste of time.

To secure *most execution at moderate and sure range* seems to me the essential character of naval gunnery as distinguished from land gunnery. If that be agreed upon, I now proceed to see how we can get most use for that end out of our 12-ton gun.

I say then at once, that you will get much more practical good out of your 12-ton gun by giving it a large bore of 12 inches, than a smaller bore of $8\frac{1}{2}$ inches.

In a 12 inch bore, the powder-power propelling the shot is 144.

In an $8\frac{1}{2}$ inch bore, the propelling power is 72.

Or the work done by the 12 inch bore is double that done by the $8\frac{1}{2}$-inch bore.

For the present I confine myself to this statement; I will prove it later on.

Next, I will take the question, how shall we turn this double propelling power to account? We have two ways, to send out a heavier shot, or to send out the same shot with higher speed.

Now in regard to weight of shot I may observe, that as you have fixed the weight of gun I shall consider the weight of shot as fixed also. Your gun weighs 12 tons, that is 240 cwt. Now, according to the best practice in all countries, the normal shot is 1lb. of shot to each 112lbs. of gun. This gives for the 12-ton gun 240, or 12-ton gun (240 cwt.) 240lb. shot.

Taking, then, 240lb. shot in an $8\frac{1}{2}$-inch gun, and 240lb. shot in a 12-inch gun, we have double the powder power propelling the same shot; or double the propelling force pushing forward the base of the shot. Therefore, the same weight of shot will be discharged with much higher speed.

Now speed of shot is, as you know, a much more effectual means of destruction and penetration than mere weight; double weight of shot has double penetrating power; double speed of shot has fourfold penetrating power. The larger bore has, therefore, the great advantage of giving higher speed of shot and greater penetrating power.

Double weight gives double destruction.

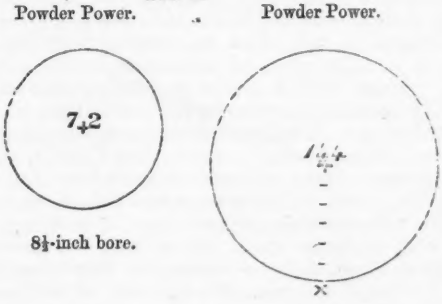
Double speed gives fourfold destruction.

The next element of efficiency is the power of the hollow shot as

an explosive shell. I need not prove that with the same weight of piercing shell, the larger bore admits of much larger explosive effect of the shell.

Thus, then, in all these ways, viz., greater initial speed, greater destroying power, greater explosive effect, the large bore 12-ton gun is more effectual for naval use than the smaller bore.

FIG. 1.



So much for the power of the larger gun for more work. Next for its own power of endurance.

I now proceed to show how, by wise arrangement, this larger bore gun of 12 tons may have more endurance than the small bore gun also of twelve tons.

I shall be told at once, that it is quite true that my large bore has greater propelling power on the shot than my small bore, but that the powder in my large bore has greater bursting power on the gun-barrel than in the small bore. This is quite true, but it is true in quite different proportions. The *propelling* power is as 72 to 144. The *bursting* power is as 102 to 144. This gives a clear balance in favour of the large bore of 144 to 102, or of 42 per cent. gain.

Propelling powers 72 to 144.
Bursting powers 102 to 144.

But I shall next be told, that my larger bore of given weight, must be thinner than the small bore of equal weight, and therefore weaker. I will show that it is thinner, but *little* thinner, and that this thinness has as compensation a better distribution of material to stand the strain, and that the balance on the whole is in favour of the large bore.

Taking then, say an 8-inch gun, as simpler for comparison than an 8½ inches, an 8-inch twelve-ton gun would be 12 inches thick, a 12-inch gun would be 10½ inches thick, or a loss of thickness of 21 to 24, but the better distribution of strength is as 13 to 9, or as 26 to 18. Combining these proportions, we find the gain in efficiency to do more than compensate the loss in thickness; the resulting gain being as 54 to 43. See Figs. 4 and 5.

Summing up the result, the larger bore is the more lasting gun.

Thinner metal . . . . 21 to 24 } Gain 54 to 43.
More effective distribution 26 to 18 }

The next question is Mode of Rifling. On this I have merely to say, that I have always been the consistent advocate of an accelerating twist for small-bore guns with common powder-charges. But for large guns with new and well regulated powder-charge, I am of the opposite opinion. For large guns, with regulated powder-charge, we must lay aside accelerating twist and come to uniform twist.

My reasons are two; first, accelerating twist injures large guns; second, it is rendered quite unnecessary with a regulated powder charge. [Third, with a regulated powder charge and uniform twist we greatly increase the safety of the gun and the safety of the shell.]

To satisfy you of the correctness of my conclusion, I must first allude to the action of a common, or as I call it, an "unregulated" powder-charge. Take a bagful of gunpowder and stuff it into the chamber of a gun in the common old fashion, and what do we get? A sudden, instantaneous, violent shock of bursting explosion. This is just what we do not want. It weakens, if it cannot burst the gun. But what is worse, it does not move the shot forward, except through a small portion of the gun. Next it falls off and ceases to drive on the shot when we most want it. It does least good with most harm. This I call an unregulated or destructive powder charge. Some people call this quick-burning powder, and think they cure the evil when they give us slower burning powder. But if they merely do this, they cure one ill and make another.

What we want, is not slow-burning powder, nor quick-burning powder; but a powder-charge that will burn quick when we want it quick, and slow when we want it slow. Or what I call a regulated charge.

Let us then consider how a powder-charge ought to do its work for us, so that it will get the most useful work done by the gun with the least harm to the gun itself.

The answer is simple, clear, and absolute. If you want to give 1660 feet per second speed to your shot at the gun's mouth, with least strain on your gun, you should drive it as follows. I use the word "*instant*" for $\frac{1}{1000}$ of a second of time, and I express the movement of the shot in inch-lengths of travel along the barrel.

	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.
Instants of time	·001″	·001″	·001″	·001″	·001″	·001″	·001″	·001″	·001″	·001″
Movement of shot ..	1 in.	3 ins.	5 ins.	7 ins.	9 ins.	11ins.	13ins.	15ins.	17ins.	19ins.
Travel of shot	1	4	9	16	25	35	49	64	81	100

Thus we see, first, that the travel of the shot begins slow, grows fast, and ends quick. If then we wish the powder to do its work with least pressure and no waste, the powder must fill the space behind the shot with steady force, in quantity, as it is wanted.

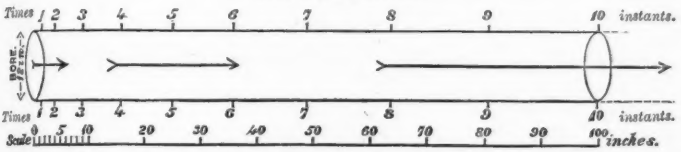
How is it wanted to burn? Thus, in the first instant, say 1 ounce

will fill the space with the uniform pressure wanted to move the ball one inch. If so, 3 ounces will have to be burnt to fill up the additional 3 inches behind the shot with the same pressure. In the third instant 5 ounces must be burnt to fill up the 5 inches of path of projectile, and so we see that the powder-power ought to be so developed as to burn very slowly at first and very quickly at the end, growing as the shot goes.

In other words, you want slow burning of powder at first, gradually growing quicker and quickest at last!

FIG. 2.

Bore of 12-inch gun, showing place of shot-base at each instant acquiring speed of 1660 feet per second.



Now, if you can get that done, your guns will last longer than they have ever done, your shot will go further, and faster, and steadier than they have ever done, and your whole work will be better done than ever.

We now meet face to face the next question, have we got such regulated powder-charges as I speak of? The answer is no, very much the reverse; then the next question is, can we get them?

I answer, "say you wish it," and you will get it. Plenty of clever men will give it you if you unanimously and strongly will it.

Of course, I see how I can do it, or I should not, as a practical man, recommend you to do it. I will show you two ways to do it.

First, in order to regulate your powder-power in great guns, you must take trouble. The same trouble we take in our guns for grouse-shooting and deer-stalking. You must get proper cartridges, skilfully prepared beforehand, and carefully stored ready for use. I recommend you, for great guns, metal cartridges, such as you have for little guns. Get these metal cartridges carefully, wisely, exactly made. If you choose to do that, you can control your powder-power in a manner absolutely certain and absolutely safe, and you can make it discharge itself exactly as you wish.

Take this (diagram Fig. 3) as your cartridge, sixteen inches long and a foot in diameter. Pack that up in a metal case, and if I had anything to do with it I would solder it up (not hot solder of course), and make it absolutely air and water tight. The cartridge should be built up in hollow cylinders of gunpowder, just as you would build a gun, those cylinders of gunpowder being made as solid as you make your pebble powder, or more solid if you like; then fill the entire of the cartridge with condensed powder so arranged that combustion should take place from the centre. Now you know, on a small scale, we have what is called central fire, but on a large scale we have never yet perhaps thought of it. But what I say to you is this, that I have

mathematically ascertained, and practically proved, that if you will bore that hole in the centre of a solid cylindrical cartridge, and burn that from the centre, then you will see that the area exposed to the flame in the process of combustion will burn your cylinder in this manner: it begins burning there (diagram), and in the first period you will only have the inch round in the act of burning, but when the inch has burnt off observe the hole becomes two inches round, and the cylinders expose larger and larger surfaces to combustion as the process of combustion goes on. The result is this, that the size of those surfaces in these built-up cartridges increases in precisely the ratio of these numbers I have shown you.

Diagram of Concentric Cylindric Cartridge.

FIG. 3.

Regulated 12-inch cartridge producing maximum speed of shot with minimum strain of gun.



You will now see that common powder cartridges and even pebble-powder cartridges, have exactly the opposite qualities of these regulated ones. They inevitably burn quickest when we want them slowest, and slowest when we want them quickest.

The diagram shows you how we can have the powder-power developed exactly in the proportion, speed, and strength we want. As to quality of powder or other explosive matter, we choose it as we want, and the cartridge regulates it to suit our work.

Now that we have got a powder-cartridge of regulated power, our difficulty about rifling disappears. The uniform twist gives all we want. The acceleration of the revolution of the shot goes forward exactly with the same uniformity as the acceleration of the shot, and so all we want is attained; the pressure on the shot both ways is perfectly uniform, and so is the acceleration, and both with the least wear and tear, both of gun and of shell.

The next point, I have not yet touched upon, is perhaps the most important for you to decide. Do you prefer having to load your 12-ton gun from the muzzle or the breech? You, not I, must decide.

All I can do to aid you, is to tell you what I know. I know that a breech-loader is not weaker than a muzzle-loader—properly made, rightly proportioned and wisely used. I quite admit that a breech-loader requires a wiser man to design it and a cleverer man to use it. But I need not tell you also that a fast ship requires a cleverer man to handle it than a slow one! The better weapon deserves and should have the better man.

Believing then, as I have long done, in breech-loading, I can only entreat you to adopt it at once and without delay. Do not let our past blunders discourage you. Let us at once frankly admit, that we were unwisely committed to a bad system of breech-loading. That

we wisely gave it up. But now that universal experience shows the advantage of a wiser system, let us candidly confess our blunder, and substitute a wise system of breech-loading for our large-bore naval-gun.

Now I will not dogmatise about systems of breech-loading. Of the French system for large guns, I have seen much and studied it for many years. I prefer it to the German system for naval large-bore guns. Sir Joseph Whitworth's system has many of the merits of the French system with some of its own. But of that you are the judges, not I.

As I have spoken of the cartridge and of the mode of charging the gun, I may say a word on the shell for our 12-inch 12-ton gun. By our 12-inch bore we can get a magnificent explosive shell. With our uniform twist of rifling we get rid of studded shot with their dangers and inconveniences, on our large scale. With uniform twist, we can get a long, smooth, perfectly fitting bearing between our barrel and our shot, in the lands or on the ribs, as we prefer.

What I have to say about the shot for our purpose, that is, for naval shells against armour-protected ships, at moderate range, is shortly this: I do not find the rounded point, or oval or parabolic form the best; I know that a conical-ended shell is stronger and better suited for penetration and destruction than any other form. I do not say that an oval point or parabolic is not the best form of shot for long range flight. I do not say that a cylindric point, like Whitworth's, is not the most perfect instrument for penetration; but even Whitworth gives his flat point a cone to some extent. What I say is, that for an explosive naval shell, conic ends are best for strength.

I have still to add something on the structure of gun and the best material for our 12-ton 12-inch naval weapon.

1. My opinion is very strongly in favour of having your great gun very nearly all in one piece. I do not think a great gun, made up of many pieces, is reliable. It seems to me to resemble *patchwork*. If you bring too much strain on one of its pieces, the piece flies and the gun is lost. If I cannot have it all in one, then I should make this condition, that the inside tube should be all in one piece, and the outer tube or cylinder also all in one piece, each containing, and reinforcing, and so helping the other. After that the fewer patches the better.

As to the material of which our naval gun should be made, there need now be no doubt. Steel and iron can now be made of any required quality, and nearly any quantity in one piece. I know that the 12-ton 12-inch gun, we have been discussing, can be made of Whitworth's condensed, tough, powerful steel, in two concentric tubes or cylinders, an outer and an inner tube. I dare say that our engineers at Woolwich will be able to make you the outer body of that gun in one piece of wrought iron, with an inner single tube of Frith's steel. By-and-bye, if you desire it, the gun may be one whole; but at present I prefer to have it in two layers, outer and inner, but each extending the whole length and not in patches.

In regard to the material of the shell, I must leave it to the result of your own experiments to decide whether for actual engagement with an enemy, you ought not to have the *very best steel* shells for

effective penetration and for security from premature explosion. Cheaper shells might be good enough for practice, but I consider that when you come within short range of your enemy, there is no shell, however costly, that should be reckoned "too good" for him. In short the most effective would be really the cheapest.

In regard to gunnery and gun-carriages, I think that when you have resolved to adopt breech-loading, matters are simplified very much. I think the existing naval gun-carriage as designed by Captain Scott, R.N., is an extremely good one; I also am of opinion that for certain special ships of war, the gun-carriage of Major Moncreiff, offers very important advantages in use, and facilities in application.

But the most important of all gun-carriages is the ship herself which carries the great guns we are now discussing. Unless the ship herself possess all the qualities of a handy, quick, steady, secure gun-carriage, nothing we can put on board of her will enable her to win a battle at sea. My own opinion is quite made up as to the qualities our ships should have as gun-carriages, and how these qualities should be gained. But that subject is too large for this occasion.

What I should desire you, the sailors and artillerists of this meeting, to agree with me in, is especially the narrow question, what is wanted for our standard naval gun? and I should wish you to confirm me, or correct me as to the following conclusions:—

For the Standard Naval Gun.

Strain on each layer.

Is 12-tons a manageable weight?

Is 12-inch bore a good size for a naval shell?

Is uniform twist in large-bore-rifling to be preferred?

Is regulated production of powder-power expedient?

Is a built up uniformly accelerating cartridge practicable?

Is continuous-groove-rifling better then studs in large shells?

Is it to be desired that the strongest, toughest steel be used, both for guns and for shot and shell?

Should the 12-ton 12-inch gun, be made in only two cylindric tubes?

Should simple practical breech-loading be adopted?

Are the existing naval carriages efficient?

My attention has been called to an omission that I have made. These figures represent one of these difficulties which I have omitted to allude to in the making of heavy guns. I did intend to have introduced that subject at the end of this lecture, but it was already too long. Some of my naval friends said to me in coming here, "You are confining yourself to a 12-inch gun and a "12-ton gun, why not have a 24-ton gun, and a 36-ton gun, and a "48-ton gun," and so on. I have investigated the whole of that subject, and let me tell you that there are great disadvantages in very heavy and thick guns, which are all explained for you in the accompanying table.

FIG. 4.—8-INCH 12-TON GUN, 12 IN. THICK.

Weight increasing with thickness.

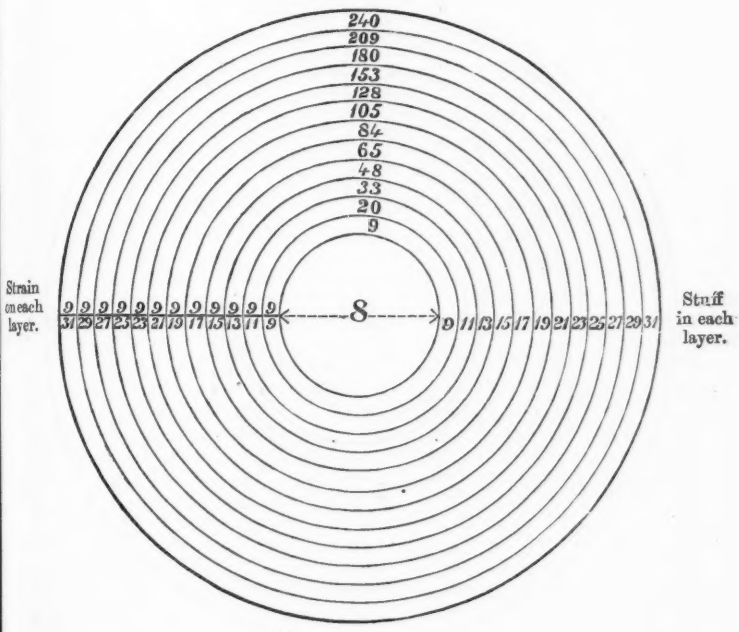


FIG. 5.—12-INCH 12-TON GUN, $10\frac{3}{4}$ IN. THICK.

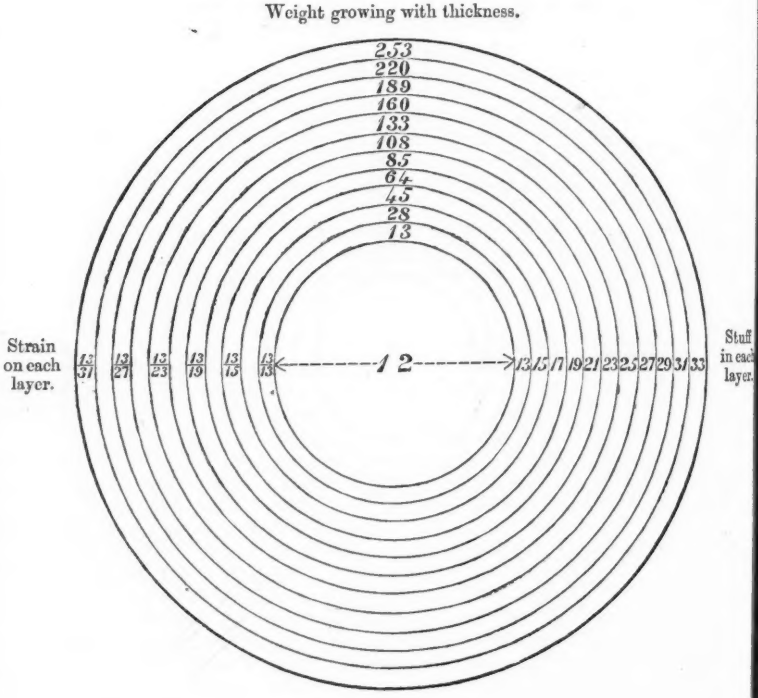


FIG. 6.

Cwts.		Tons.		Weights of each successive thickness.			Efficiency of each successive thickness.
108	..	5·4	..	108	13 × 1·000		
					15 × 0·866		
					17 × 0·764		
					19 × 0·684	·749.	
					21 × 0·618		
					23 × 0·564		
288	..	14·4	..	180	25 × 0·520		
					27 × 0·471		
					29 × 0·448	·435.	
					31 × 0·418		
					33 × 0·393		
					35 × 0·360		
540	..	27·0	..	252	37 × 0·341		
					39 × 0·322		
					41 × 0·317	·309.	
					43 × 0·302		
					45 × 0·288		
					47 × 0·276		
864	..	43·2	..	324	49 × 0·265		
					51 × 0·255		
					53 × 0·244	·241.	
					55 × 0·236		
					57 × 0·227		
					59 × 0·219		
1260 Total weights.	..	63·0 Total weights.	..	396	61 × 0·213		
					63 × 0·205		
					65 × 0·199	·196.	
					67 × 0·193		
					69 × 0·187		
					71 × 0·183		

Stuff in each layer.

The explanations in this table show you how round your 12-inch gun you could put coating after coating, thickening it all the way, until you made it up, as I have done here, to a 63-ton gun—I believe, in fact, you are making an 80-ton gun. This being the radius of the gun, I call your attention to this important point. The first coating on the skin of the gun does its full work, say a coating an inch thick of iron or steel; and, therefore, out of the first inch of the gun I get the full per centage of its work—a hundred per cent. we will say. The first inch thick of the gun would weigh 13 cwt., and that 13 cwt. would do its full work, or 100 per cent. The next coating would weigh 15 cwt. more, now we have the gun two inches thick, and it would only do 86 per cent. of the work the first inch did. The next one would weigh 17 cwt., and only does 68 per cent. of the work; and as you grow in the thickness of your gun we have now got 108 cwt. in the first six inches, but mind, the average per centage that that is doing of useful work is only 75. If you say make this gun six inches thicker you add 180 cwt. to the weight we had before, and this 180 cwt. does diminished work, the sum total being only 43 per cent. of useful work. Now go on and add six inches more, there is the weight of each of the layers an inch thick, and I add 252 cwt. more to the gun, and with this 252 cwt. I only get 30·9, that is about 31 per cent. of useful work. With the next six inches I add 324 cwt. to the weight of the gun, and only get 24·1 per cent. of work out of

the whole of that, and if you insist on it I will go six inches more, but I am tired now, and I hope you are; 396 cwt. I have added to the gun, and the per centage of useful work out of that 396 cwt. is only 19·6. Now what have you got? You have got a gun which began with 5·4 tons, which you then raised to 14·4, then to 27 tons, then to 43 tons, then to 63 tons total weight; and every ton you added became of less and less useful value as you added it. That is the reason why I do not recommend to you guns of excessive weight; and when in the future you hear of a great gun of enormous weight, will you please keep in your memory this column of diminishing efficiency? If you want a good gun, you must make a large bore to lighten the pressure upon it, that will give endurance to your guns, and then you must use the metal in a moderate quantity instead of an excessive quantity; you will then get a much higher duty out of the metal, but the way of doing that is to select with infinite care the qualities of your metal. Do not let the word "steel" touch your minds; do not let the word "iron" touch your minds; do not let the word "alloy" have anything to do with it. Every one of us has his crotchet (I know I have mine), take the most perfect metal of the largest strength, of the greatest toughness, of the utmost reliability, in the right masses, and in right shape to be an enduring gun, and do not trust to mere bigness, it is a fallacy.

Captain R. A. E. Scott, R.N.: To grasp all that Mr. Scott Russell has said is exceedingly difficult, but still I think I can corroborate in some measure a few of his points. The endurance of one or two of the Palliser lined guns has heretofore been a matter to me of very great surprise. The wrought iron tubes of these guns we put *slackly* into their reamed out cast iron envelopes; hence it is evident that the cast iron can give but little support to the tube inside it; and yet, strange to say, one of these Palliser lined guns showed greater endurance than one of the wrought 64-pounders, built up as these guns are at the present time with a great mass of coiled metal at the breech. Without fully accepting the figures given, I think this experiment shows that there is a great deal of truth in them. Again, most of you are aware that one of the earlier 600-pounders burst after a few rounds. It seemed to have split coil after coil throughout its thickness, indicating, as it seems to me, that the coils do not act in unison on a sudden shock, and hence that the sum of strength of the superposed layers of coils represents far more than the actual strength of the gun. If you compare the Palliser lined gun, and our own wrought iron gun, it seems clear that if the inner tube in the one case ought to be put in slack, it ought to be put in slack in the other, whereas in our built up guns the inner tube, and likewise all the coils over it except the outer one, is subjected to very great compression in order to bring the other parts of the gun into play to resist the violent shock of discharge. In fact, the built up coil gun is in a state like a very tight string, and hence a sharp blow is likely to cause its destruction. I think one of the guns which broke in pieces was burst very much in this way. I do think our guns are not of the right shape—they are a great deal too thick at the breech, and too thin at the muzzle, especially for the present slow burning powder. We could afford to take off a large quantity of metal from their breech. What Mr. Scott Russell says as to a gun being made of two layers only, viz., an inner tube and an outer one, I believe to be very nearly correct. I do not think you want many layers of metal, but what you do want, is the very best metal, especially for the inner tubes of our guns. The best metal I know of at the present time, but it has not yet been produced in large quantities, and is consequently very expensive, is Sir Joseph Whitworth's fluid compressed steel. The whole question as to the best naval gun and projectile is of the utmost importance to us.

Captain Colomb told us in this Institution, and with truth, that the power of the guns was receding as compared with the size of our ships, and, doubtless, as we are lessening the number of guns, and increasing the thickness of armour, we are really obtaining defensive mail at the cost of gun power. I do not mean to say that the introduction of a few large guns rather than numerous small guns is wrong, but I wish to bring out this point, that in proportion as fewer guns are carried, accuracy is of more vital importance. Not only must there be accuracy, but when the shot strikes there must be a certainty of penetration, but that certainty of penetration does not at present exist. The studded shot are very brittle, the largest being first wounded with thirty-six holes in their sides, and then having thirty-six buttons stuffed into these holes under powerful hydraulic pressure. The consequence is, if you give these shot a hard tap, or even subject them to sudden changes of temperature, they are liable to split, and as a matter of fact, we have had numbers of such accidents with studded shot. Returning to the question of the very few guns some of our armour-clads are carrying, I would observe that an armour-clad is not so fast as any unarmoured ship, and unless the ironclad has efficient artillery, an unarmoured ship may keep ahead of and spot her as she is either rolling or pitching deeply, or rising with her forefoot nearly out of the water, and thus leaving a very large unarmoured surface exposed, and which could be hit very easily. We have not as yet nearly attained to the accuracy which we shall hereafter attain, and which we ought to have long since reached. Another point in this important matter is, that our experiments have been hitherto made in firing at plates placed at right angles. In a naval action, however, the shot will very seldom strike at right angles, but almost always at a very acute angle, so that judging from our experiments, it seems to me that the present weak projectiles will produce a very small effect indeed upon an enemy. For the Navy, therefore, it is most important that we should have in lieu of such untrustworty missiles the very strongest projectiles (punches) that can be manufactured. Hitherto there has been no attempt to carry out a series of practical experiments, and there has been no real competition with heavy guns; I speak this advisedly, for in the so-called seven-inch competition there were no live shell fired, there was not a single shot fired against an armour plate, there was no test of the endurance of the guns, nor was there any practical test whatever, and hence it is not surprising that the gun selected, viz., the French gun, very soon afterwards split through its inner tube. Any one may see at a glance what must be the effect of rotating a shot by means of studs, and why our guns have a very small endurance; in fact, these stud bearings do not even stop the rush of gas past the shot, and hence the gun becomes rapidly eroded in its inner tube; the shot also, from not being held firmly by these weak studs, strikes against the bore, and thus very soon succeeds in cracking the inner tube of the gun. The 35-ton gun had to be re-tubed after a very few rounds; it then fired a few more, and was turned over and re-vented, and I believe at the present time it is in rather a shaky state. This lack of endurance is not what we require for a naval gun. It is of immense importance that those who have to sail in our war ships should have guns that will not only enable them to fight one action, but that will have sufficient endurance to enable them, especially when on foreign stations, to fight continuously. In war, a gun may have to fire a very great number of rounds before the ship carrying it can go to a dockyard or arsenal; and it is of vital consequence to the Navy that its guns should not deteriorate so very rapidly as they now do. The worst of any deterioration is, that the action of the studs on the damaged parts tends to dig little pits in the inner tube, so that besides the weakness ensuing from deterioration, there is another element of danger from the hanging (or detention) of the shot in the bore. Even were there no obstruction in the gun, the shot, if it cracked, would naturally break through its weak part, the stud-holes, which are just opposite the rifling, and damage the grooves; and, as a necessary consequence, you could not load your gun. One bad effect of our present experiments is, that no man commanding a ship knows at what angle his shot will penetrate an enemy. I believe that the 64-pounder (the gun chiefly used afloat), stud projectile, would break up harmlessly if it struck obliquely against an unarmoured ship's side; but we have had no experiments to test this, or to test the relative power of penetration of our different shell. Instead of continuing in this dangerous

groove of ignorance, we urgently want, at the present time, a full inquiry extending over the whole subject of Naval Armaments; and there is this important collateral question in relation to it, whether we have not gone on loading our ships with armour without due reference to other requirements. In what position do we now stand? The ram is well nigh useless, because the torpedo keeps its use in check, and hence the gun is more important than ever to us. What we now need is a careful consideration of all these points, and a trial with say a hundred rounds of the best projectile made of one metal only, to be tested against the system which has been built up upon no solid foundation. In such a trial, the value of each point should be first settled, and then the shot fired for accuracy, might also be made to test the endurance of the gun, as well as ease of loading, strength of projectile and every other requisite for a naval gun. Angular firing against an armour-plate is an experiment so simple and so little costly, that I should be very happy to try the long bearings—that I have advocated—at my own cost. Then you may say that any change in the manufacture of projectiles, &c., would be very costly, but it really is not so. Mr. Scott Russell has shown you the great thickness of the main tubes of our guns. I believe their thickness is beyond what is necessary; and, therefore, it would be a very simple process to re-rifle the guns for the Navy, and to use the Navy ordnance and projectiles we now have in shore batteries. At present we must do something to increase the endurance of the guns, and hence are obliged to fasten on to the rear of our projectiles a large lump of brass called a wad. This wad will not, however, stick on, unless the shot are expressly cast for it, so that we must, in any case, provide new shot for the Navy. As for the big guns of 25 and 35 tons, they are of the same 12-inch bore, but they will not fire the same projectiles, one having a much sharper rifle-twist than the other; the 38-ton gun has a still sharper twist, and also a larger, viz., a 12·5 inch bore; therefore, there are three heavy guns very nearly alike, and neither of them able to take the same projectile. This useless multiplication of projectiles is a very serious evil. What Mr. Scott Russell says of the powder cartridges is, I think, practicable, and I am very much inclined towards the breech-loading apart from the question of the rifling. I think some years ago we accepted muzzle-loading, and have since held to it on account of its simplicity; but now that we have gone into such large guns as to necessitate hydraulic loading, and hence got an arrangement very liable to damage (for a valve going wrong would put the gun *hors de combat*), I think we can very well afford to go into breech-loading, which is comparatively simple. As these questions concern the future of our Navy, I can see no valid reason why there should not be a thorough and exhaustive inquiry that should look a little outside the official groove we have at present got into. One word more as to our ships; I have hesitated a good deal as to saying it, but I think I may venture to assert, by our belief that we have been piling on armour with the idea that our ships are always to be hit at right angles, that the great weight now carried in armour would have been much more efficiently used if it had been carried as guns, coals, and the other requisites needed by a war steamer. I believe our very heavily armoured ships are a great mistake; and, looking at their large area of vulnerability, I think that if two smaller unarmoured ships were to attack one such armoured ship on either bow, and to fire at her both when she lifts to the sea, and when she pitches bows into it, that the ironclad would run a very poor chance indeed.

Admiral Sir HENRY CODRINGTON, K.C.B.: The lecturer seemed to be under a mistake in thinking that this meeting should pass a vote. We are here as members of this society free to entertain our individual opinions, but we do not vote. Nor could we give an effective expression of opinion. It would be contrary to the rules of the Institution. There are, however, one or two points I wish to ask about. Is the rear of that cartridge to be open?

Mr. SCOTT RUSSELL: No, closed, fired by concussion through the closed rear; no combustion behind.

Sir H. CODRINGTON: I wish to ask upon what do you base the calculation—it seems a very good one—of the time and distance of the shot going on in its passage out of the gun.

Mr. SCOTT RUSSELL: On absolute mechanical principles; I undertake to demonstrate by physical or mathematical demonstration that that is the method

which unites the greatest velocity with the least strain. Permit me to say also it is the same law as that of accelerating gravitation; the same law as that of the steam engine or of any other propelling power.

Sir H. CODRINGTON: I think, in advocating the larger diameter of 12 inches, there is one thing lost sight of. You say there is greater initial velocity in the proportion of 144 to 72. What is the velocity at 2,600 yards distance? that would be the point; because, after all, it is not always the velocity at which the projectile leaves the gun, but the velocity at which it strikes the object. If that large diameter meeting the resistance of the air is slackened in its speed considerably, then the small diameter, though starting at less initial velocity, may be actually striking the heavier blow. Am I to understand that there is a different amount of powder in the 8½-inch gun, or is it the same amount of powder?

Mr. SCOTT RUSSELL: Which way you please. If you wish this (the 12-inch) to exert the greater power, you put in more powder.

Sir H. CODRINGTON: It is not the same?

Mr. SCOTT RUSSELL: Not the same powder-power.

Sir H. CODRINGTON: I presume, also, that the more elongated shot will have the steadier flight, and particularly at a distance.

Mr. SCOTT RUSSELL: Quite true.

Sir H. CODRINGTON: Consequently, it would have more penetration and more accuracy. I should be against entirely arming a ship with guns of the larger diameter, though I fully agree with their advantages. I would rather have a chase gun, because there is another thing we have to do—not only to fight our best when within 1,000 yards, but also for distance firing when in chase, and to bombard fortifications, &c., at a distance, where we want extreme flight with a very fair allowance of accuracy, which the other would not give.

Mr. SCOTT RUSSELL: I am very pleased to answer these questions, for they simply supply omissions. In the first place, to both these shot I can give 1,660 feet velocity. That somewhat answers the question, because, with 1,660 feet initial velocity, you are able to get all you want for an ordinary naval gun; but I quite agree that the larger shot, if the velocities are equal, will encounter the greater resistance; and, therefore, I was not satisfied, any more than you may be, with being able merely to propel this larger diameter of shot; and I found out that there were laws well known to other countries, if not by us, by which (and this I must ask you to grant for the present without discussion) a shot of small diameter, a rifle shot of small bore, is capable of being fired out of a gun of larger bore with the same precision and with much higher initial velocity than out of its own gun. Therefore, permit me to say that one of my reasons for confidently recommending to you to choose the 12-ton gun is this:—that I will take the shot of the 8-inch gun, that I will put it into the 12-inch gun and will send it out for you with higher velocity, due to its higher propelling power, and with the same precision. That is a serious question, which, if you choose, we will discuss another night; but I undertake that you will, and but for that I should not have recommended it to you. I am entirely of the Admiral's opinion that, while we might choose to take a gun of this weight for the ordinary broadside armament of a ship, I should go back to our nice old-fashioned custom of having a *good long chase gun* in the bow, provided I had found that that good long chase gun would give me the qualities for practical purposes that this shorter gun would not, but in that case I should not diminish the bore of the gun. I should keep the same bore, and should only do as we did in old times. My pet gun was the 65-cwt. 8-inch gun, but the 95-cwt. 8-inch gun was the gun we put in the bow of the ship, and, therefore, if you find that our 12-ton gun of 12-inch bore, which is probably 14 feet long, is not all you could wish for for the bow gun—I think it may be more even than you expect—but, if you find it is not all you could wish, no man would more energetically go with you in the desire to make the bow chase gun, a 12-inch gun, but a heavier gun, with a longer range and greater precision for exceptional purposes. And, if you please, let us talk of the 12-ton 12-inch gun as *the ordinary standard naval gun*, and then let us also have *exceptional guns* for exceptional purposes. I think that reconciles all differences; but, take my word for it, you can fire the small bore shot with perfect precision and far greater velocity out of the big bore gun.

Sir HENRY CODRINGTON: There is another point about the penetration of a shot of a diameter of 12 inches compared with the penetration of a shot of the diameter of 8½ inches. I have always understood that 8½ inches would have the greater penetration, weight for weight, and velocity.

Mr. SCOTT RUSSELL: I perfectly agree, as to the greater penetration of the smaller shot, and that is why I am so pleased to be able to tell you that your elongated smaller shot, when you wish that peculiar kind of work, can be fired out of that same 12-inch gun at the higher velocity. I think that gets over the difficulty. Do you not think it does?

Sir H. CODRINGTON: I think it does.

Captain HORTON, R.N.: May I ask Mr. Scott Russell whether that practice of firing the smaller projectile out of the larger bore involves breech-loading, or whether it is practicable from the muzzle also?

Mr. SCOTT RUSSELL: I have only seen it practised with breech-loading, but I cannot see the difficulty. The shot I am acquainted with is one which I see no great difficulty in putting in to a muzzle-loader than any other. You will understand it in a moment when I say the lifting would be identical in the two cases.

Sir H. CODRINGTON: Would there be no oscillation of the smaller projectile, and no deterioration of the gun?

Mr. SCOTT RUSSELL: None whatever.

Mr. MACOMBER: I should like to make an observation or two in relation to Mr. Scott Russell's paper, to which I have listened with very great interest. I only wish to ask a question or two, leaving it for him, if he pleases, at any time, to settle it. What is the difference between the strain of the inner part and the outer part of the breech of a gun? The demonstration made by the gentleman is most excellent. We know that it diminishes, but the question of the proportion of such diminution does not seem to be settled. One other thing I wish to ask. Supposing there was a method by which the strain upon the gun could be entirely equalized, so that the strain should go upon all the outer metal in the same proportion in the same instant of time that it does upon the inner, would, or would not, that be an advantage? Again, would it not get rid of all that extra metal which is so admirably shown by Mr. Russell, and is so well understood, and would it not, under those circumstances, be an advantage by which we should be able to use less metal and still retain greater strength?

Mr. SCOTT RUSSELL: I think the speaker and I are entirely at one. I think if you could obtain a method by which you could turn the strain of the outer coating, utilize, I call it, the strength of the outer coating as completely as you do the strength of the inner coating, you get a manifest gain; but I suppose the speaker, who is well known as a gun-maker, knows very well that we have tried a good many experiments in this country on that subject, which have not been very successful. I think some of our most famous gun-makers put the outside of their gun into an extreme state of strain, and in such a manner that they believed that they had so adjusted it that the strain which was already put on the outer one relieved the inner one in such a manner that when the inner one was strained, they came, in the end, to exactly the same state of tension. Of course, if that were done, I admit that that is an advantage, because a thinner gun endures a much higher strain, and there is much less likelihood of the rapid destruction of the gun; but in the peculiar expedients that we adopted in this country—and some of our cleverest men adopted them—there was admitted one element, the element of time. It was discovered about twenty years ago, by a very great man at Manchester, called Mr. Hodgkinson, that time has a wonderful effect in changing the condition of matter under strain; and so it was proved that those people who had put the coats of their gun into an artificial state of tension for the very object mentioned by Mr. Macomber, made very good guns the first day, but which were less and less perfect every other day. It just reminds me of a man who had a great establishment in London, in which he could make the most magnificent wines anybody ever tasted, of the oldest vintages. They were perfect wines the first day; they were not so good the second day; they were bad the third day; a great deal worse the fourth day, and so on—and that is the state of guns put for this wise purpose into artificial tension, and so that has been given up. Whether there is a substitute for it I do not yet know. The only sub-

stitute I know is, to select the outer coating of the gun with one peculiar quality of tension, and the inner coat of the gun with another peculiar quality of tension, so that when the strain comes on them, the tension in each shall rise to the proper proportion on the ultimate strength of that metal. By a wise choice of the inner and outer metals, I think what Mr. Macomber says could be secured.

Mr. MACOMBER: I may be excused for another observation. I have been mentioned as a gun-builder, and therefore I must own that I have built guns; and in relation to the last observation with one gun[1] that I made, we had an initial velocity of over 2,000 feet per second, and I fired the gun myself 288 times, and after the last shot, upon examining the gun with the best instrument I could find, there was not the least change whatever in the diameter of the bore or the chase. One other observation is simply this:—I should have been very foolish to have asked the question if I could not in my own way have answered it to my own satisfaction, although not perhaps to the satisfaction of others. It is, that there is a method by which when a gun is being built, if I may be allowed that expression, you may strain that gun to a greater extent than subsequently it will ever be called upon to endure, and that, therefore, such a gun, if it does not deteriorate in the quality of the metal, would certainly stand that strain, and a great deal more; how much I do not know. The present gun that I have, has been fired with an initial velocity of over 2,000 feet per second. It is not a large gun. I should like to ask Mr. Scott Russell to give us the proportion of powder that he would use in proportion to the weight of shot, which, after all, is a very serious question, for out of a small amount of propelling power, whatever it may be, gun cotton, or anything else, you cannot get a very large effect of power, and if you have a large amount of power you may endanger the safety of your gun. Then, the next question will be to build your gun so that it may be strong enough to bear all that.

Mr. STIRLING LACON: What was the size of the gun with which you made those experiments?

Mr. MACOMBER: It was a small gun of only 1¾ inch calibre. The weight of the shot is about 3 lbs.; but, at an elevation of 38 degrees, I have thrown a shot 9¼ miles, measured with a Gunter's chain. I do not know that I could do it again. It was not with this gun, but it was with one precisely the same size. The observation made by Mr. Scott Russell is, that in increasing the size, the proportions are not kept thoroughly. I grant it, I know it to be so; and if I could get an initial velocity of 1,800 or 2,000 feet per second out of a large gun, I should get great power most certainly.

Mr. SCOTT RUSSELL: With reference to the charges of powder, I do not think it necessary to deviate much from the present charges, for if I find that this graduated system be adopted, a far higher initial velocity will be attained with a far lower charge. I dare not tell you almost how low a pressure of powder would give this initial velocity in only nine feet length of travel in the gun; and I beg to say I see no impediment in this bore of the gun to raising the 1,650 feet velocity to 1,880 feet; and if Admiral Codrington's long chase gun were added of the same bore, but with greater length, and made of the best possible material, I could undertake for his chase gun that it should give an initial velocity of 2,000 feet per second.

The CHAIRMAN: I have listened to this conversation with great interest, having been a good deal mixed up with this question of guns some 15 years ago. I have always taken a great interest in it. I still hold myself perfectly free from not admitting of course all that has been stated here. But there is a good deal with which I am inclined to agree. With regard to this 12-ton gun, I remember when I had a 9-ton gun, and mentioned that I was making some 9-ton guns for the Admiralty; and we had also made one or two 12-ton guns, Lord Hardwicke got up and said I must be perfectly mad to be making a 9-ton gun, so that I was obliged to suppress my 12-ton gun altogether. I could not say a word about it. That was the state we were in in 1860 or 1861. Since that, we have certainly advanced with our guns; whether or not we have very much improved is a very different question, and remains to be seen. I think these discussions are very useful, because they do show the differences that exist, and the great variety of opinion; and it is only by

[1] The Macomber gun, see Journal, vol. xix, page 268, *et seq.*

comparing these opinions that we shall eventually get to something very good. This country is no doubt, in point of mechanism, almost the first, or at any rate, one of the first countries in the world, and we have means with regard to metals as great as any other country. But we have not advanced, I am afraid, quite so fast as we might have done in the last 12 or 14 years. I hope, therefore, the attention that is now called to the subject will, eventually, be useful. I do not myself take any particular part either with the Armstrong guns, or with any other guns. Our original breech-loaders we were obliged to abandon. The vent-pieces blew out about our heads, and we were in considerable danger even from the experimental practice. Then we tried the shunt gun, but that has gone; then the hooped gun, that seems to be gone; and, in point of fact, we do not exactly know now where we are with regard to the guns. At any rate I think you will all agree with me in thanking Mr. Scott Russell for having called attention to this subject, and given us a very scientific and a very clever paper upon the question.

LECTURE.

Friday, May 7th, 1875.

ADMIRAL SIR ALEXANDER MILNE, G.C.B., Lord of the Admiralty, in the Chair.

SOME ACCOUNT OF THE OBSERVATIONS RECENTLY MADE BY THE CORPORATION OF THE TRINITY HOUSE ON FOG-SIGNALS.

By Vice-Admiral R. COLLINSON, C.B., Elder Brother of the Trinity House.

IT may, I think, be taken for granted that the object of setting up fog-signals on our shores is generally understood; but in case any one present is not quite clear upon the subject, I will briefly state it to be, to make certain signals by means of sound which will convey to the mariner navigating in the vicinity of land in foggy or thick weather, the same guiding or warning information as that conveyed by means of lighthouses in clear weather.

In the days when our own merchant fleet was not so extensive as now, when steam ships were almost unknown, and when the number of foreign ships visiting our shores was extremely small, the necessity for guarding dangerous localities in foggy weather was not very marked; because vessels, as a matter of fact, generally hove-to if fog or very thick weather came on while they were in the vicinity of land. Here and there on salient points of the coast, with deep water close to, bells were established, but it is more than probable that they were seldom or never practically serviceable.

But as maritime enterprise and discovery progressed, trade and navigation increased in like measure; to this increase the introduction and development of steam power gave a strong impetus, insomuch that the darkness of night ceased to be a hindrance to sea voyaging, and the demand also arose for some sort of guiding signals to enable vessels to continue their courses during fog and thick weather. Thus the question of fog-signals came before those to whom the duty of marking our coasts is entrusted. I allude, of course, to the ancient Corporation of the Trinity House, of which I have the honour to be a member. It is needless for me to bring before you the numerous, and many of them most unpractical propositions which

have from time to time been brought before the Trinity House on the subject of fog-signals. It is sufficient to say that previous to 1872, actual knowledge on the subject was extremely vague, both in regard to the production of suitable sounds and to the actual effect of any such sounds when produced. Varying and often irreconcileable statements were made as to the distances at which sounds of different kinds were audible, but trustworthy evidence on the subject did not seem to exist. The numerous proposals made to the Elder Brethren of the Trinity House were generally characterised by crudeness and insufficient knowledge of what was required; and in accordance with the rule which the Trinity House invariably follow in all matters relating to guiding signals, they were unable to adopt proposals which were based on uncertain foundations, and which gave little promise of being practically serviceable to the mariner. But although definite knowledge in regard to the application of sound for signalling purposes was in so unsatisfactory a condition, the Trinity House always kept in view the ultimate possibility of utilising sound in the manner desired, and as far as they reasonably could (being controlled in matters of expense by the Board of Trade) encouraged inquiry into the subject, and themselves at various times made tentative efforts towards bringing the question into a practical shape. Actuated by such motives, the Elder Brethren gave considerable encouragement to Mr. C. L. Daboll, of New York, the inventor of a fog-horn, sounded with compressed air and worked by means of a caloric engine. Three of these instruments were obtained and set in operation in this country; they have proved of some value, and are working well at this present moment; but as a matter of experience they have never reached the efficiency claimed for the fog-signals in operation on the coasts of the United States and Canada. All sorts of rumours came across the Atlantic as to the distance at which American fog-signals were heard; and as these rumours could only be verified by actual observation, it was deemed advisable by the Trinity Board that a Committee of Elder Brethren should visit the United States and Canada to learn what was the real value of the fog-signals in use in those countries.

Accordingly, this duty was apportioned to the Deputy Master (Sir Frederick Arrow) and Captain Webb, who in the latter part of the year 1872, went out and made a practical examination of many of the signals in use on the American and Canadian seaboards. The report of this Committee contained a great deal of valuable information, described with accuracy the various kinds of instruments used, and showed that the subject of fog-signals had been dealt with on a more extensive scale than in our own country. This latter circumstance is due to the fact that from well known causes fog is very much more prevalent on the North American seaboard than on our own shores, which physical fact, taken in conjunction with the large coasting trade of the country, and the well-known energy of American traders, clearly demonstrates that there is a greater demand for fog-signals with them than with us. The Trinity House Committee, in their report, say:—

"We found that fog-signals were used in the same way as lights "and beacons in fine, clear weather, and are trusted to almost as im- "plicitly. American vessels run by them irrespective of all considera- "tions of crowded navigation, or of other marks. * * * "* * Fog may be said to be the normal condition of the "American coasts for full one half of the year or more; ship masters "and owners cannot afford to be stopped by it, consequently they run "the risk."

But although the investigations of the Committee showed that there was a more extensive system of fog-signals on the other side of the Atlantic, yet they showed also without doubt that as regards the relative value of the various instruments used, and the propagation of sound in different conditions of the atmosphere, as much ignorance prevailed in America as in England; nothing certain seemed to be known on these points, and the reports as to the great efficiency and ranges of fog-signals on those coasts appeared to be founded on evidence of the slightest kind.

The result of the Committee's visit strengthened the desire which the Elder Brethren had long entertained of making a series of comprehensive and exhaustive experiments with the view of gaining more certain knowledge of the subject, in order that in the placing of any such signal, its value for the warning or guidance of mariners, might be more clearly known and understood. The Elder Brethren have always been averse to establishing any guiding signal, the value of which was hypothetical; they consider with their late scientific adviser, Professor Faraday, that "a false promise to the mariner is worse than no "promise at all," and it was this feeling of ignorance and uncertainty about the real value of sound-signals which has for so long a time operated to prevent the more frequent establishment of such signals round our coasts.

On application to the Board of Trade for sanction to the necessary expenditure for the proposed experiments, that department recognizing the national and cosmopolitan value of such an inquiry, at once agreed to allow the necessary expenses from the Mercantile Marine Fund. Although the Elder Brethren generally took an interest in the proposed investigation, the charge of conducting the experiments was confided to a Special Committee, consisting of Captains Drew, (Chairman), Were, Close, Atkins and myself, acting in concert with Dr. Tyndall, the Corporation's scientific adviser; and the Deputy Master was kind enough to spare his private Secretary, Mr. Edwards, to act as Secretary to the Committee, and great use he has proved to us.

The South Foreland was selected, as it offered great advantages for the prosecution of the experiments and for observations being made from sea. The means of judging distances were at hand; the point itself was sufficiently prominent to allow of a large arc for observations; the height of the cliff was advantageous for trying the effect of signals at the sea level and at a considerable elevation; the machinery used for working the electric light could be utilized for working the necessary air-pumps; and access to town was convenient.

It will, I think, be well, first to give a brief description of the instruments experimented with, and afterwards to deal with the observations made and the practical results obtained therefrom.

Instruments Tried.

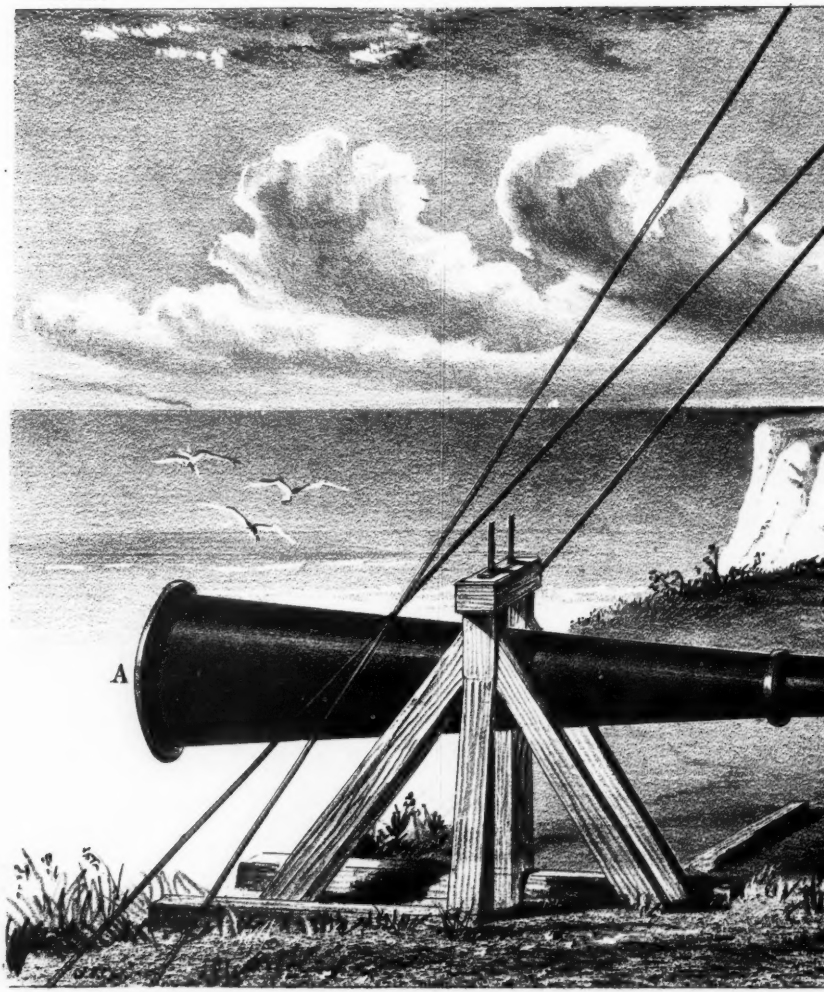
In the experiments, various kinds of instruments were tried, with a view to ascertaining which was the most effective as a sound producer. The instruments set up at the South Foreland at the outset of the inquiry, were English whistles blown by steam and air, and air-horns, or trumpets, made by Mr. Holmes. Subsequently, however, a whistle from America and one from Canada were obtained in order that there might be no doubt as to the best kind of whistles being tried; a steam siren was kindly lent for the purpose by the United States Lighthouse Board, and various pieces of ordnance were, by permission of the War Department, sent on loan from the Artillery depôt at Dover Castle. Of each of these instruments I propose now to give a short description, and to state in what manner they were subjected to trial, leaving the results of the experiments to be dealt with under the head of "Observations."

Whistles.—The whistles are five in number, as follows: Canadian whistle, cast solid, 12 inch diameter, blown by steam, 74 lbs. pressure; American bored and tuned whistle, made of sheet brass soldered to a solid top, 12 inch diameter, blown by steam, 74 lbs. pressure; 12-inch whistle, attached to a boiler, sounded by steam, 74 lbs. pressure, constructed by Mr. Bailey, of Manchester; 8-inch, blown by steam or air, 45 lbs. pressure; 6-inch ditto, sounded by steam, 74 lbs. pressure. The dimensions and adjustments of the whistles are as follows, viz.:—

	Diameter.	Length.	Lip to Cup.
Bailey's ..	6 inches ×	8 inches.. ..	$1\frac{1}{2}$ inch.
Holme's ..	8 inches ×	15 inches.. ..	$3\frac{1}{2}$ inches.
Canadian ..	10 inches ×	17 inches.. ..	3 inches.
Bayley's ..	12 inches ×	14 inches.. ..	$2\frac{1}{4}$ inches.
American ..	12 inches ×	20 inches.. ..	$2\frac{1}{2}$ inches.

The distance of the lip from the cup can be varied, with the exception of Bailey's 6- and 12-inch, which do not admit of such variation. It is sufficient to say that with the view of ascertaining the actual effective sound-range of such instruments, and their relative value in comparison with other sound-producers, they were tried alone and in combination; various pressures of air and steam were used in order to discover which gave the best result; the different notes capable of being produced by the whistles were tested with the object of proving which was the most effective; and trial was also made as to whether the sound produced was more effectually transmitted to sea from the sea-shore, or from an elevation 235 feet above the sea-level.

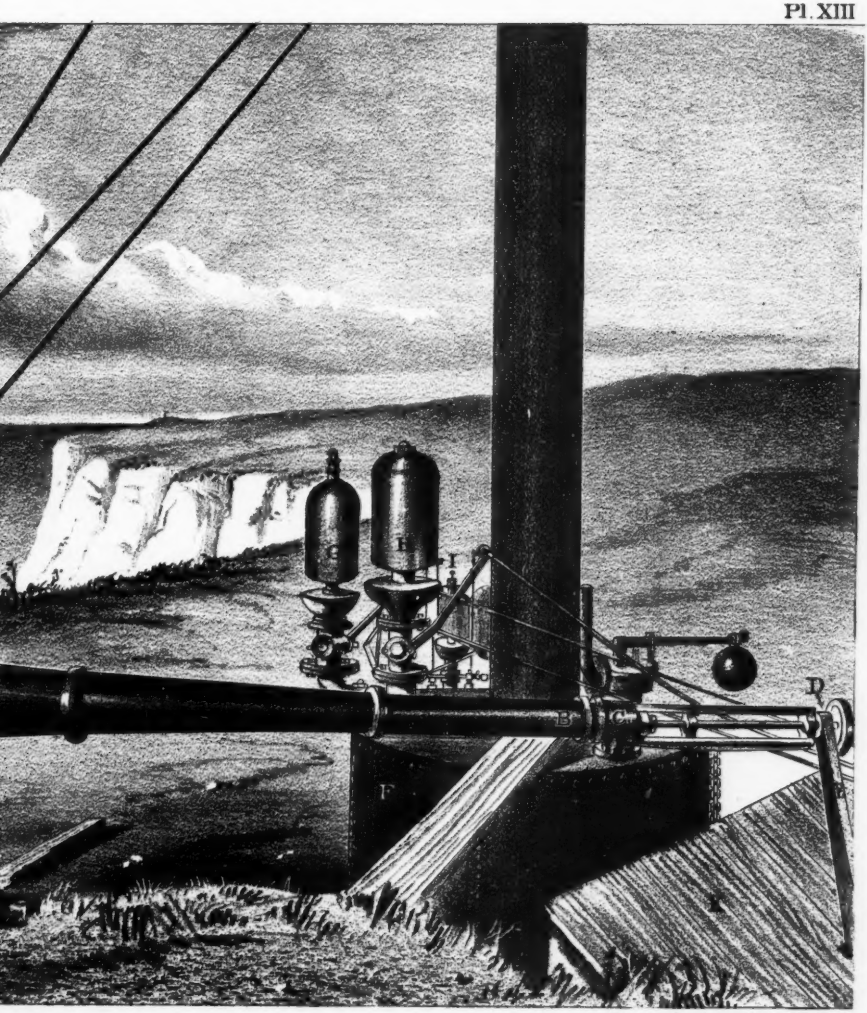
Air-horns, or Trumpets.—I have previously remarked that three of these instruments have been for some years in actual operation on our



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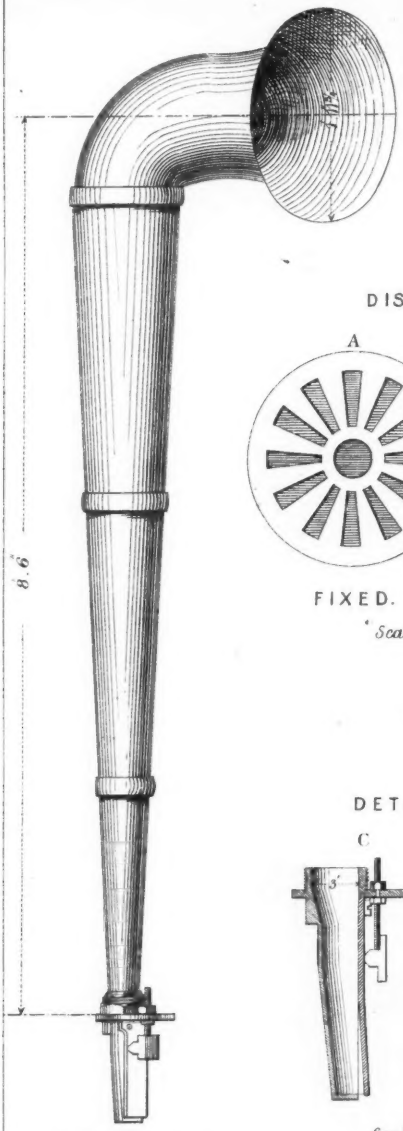
A-B. The Siren Trumpet. C. The chamber containing the Siren discs. D. The pu

E. The driving belt. F. The boiler. G. The Canadian Whistle. H. T



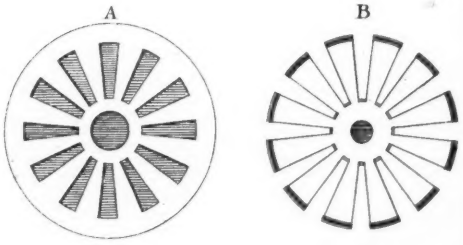
REFERENCES.

ces. D. The pulley and spindle driven by the Steam Engine for rotating the Siren disc.
Whistle. H. The American Whistle. I. Holmes' Whistle. K. Engine Shed.



Scale ⅜ Inch = 1 Foot

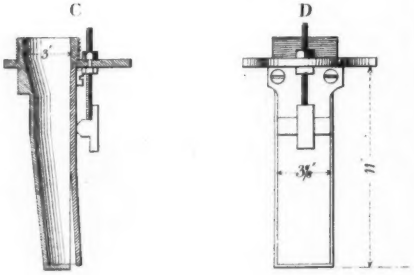
DISKS OF SIREN.



FIXED. REVOLVING.

Scale ¼ full Size.

DETAILS OF REED.



Scale 1½ Inch = 1 Foot

J.Jobbins.

coasts, and have been well spoken of by those for whose use they were established; but with the object of gaining more accurate knowledge as to their practical value, it was thought proper to have them tried with the other instruments. The horn is a brass trumpet 8 feet 6 inches long, 3 inches diameter at mouth-piece, opening out to 22½ inches at the other end. The reeds[1] are 10¾ inches long, 3 inches wide, ¼ of an inch thick, sounded by air of 18 lbs. pressure. By means of air-pressure this steel reed is made to vibrate so as to yield a note in unison with the fundamental note of the trumpet itself, the reed having previously been properly adjusted for this purpose. The air-pressure necessary to awake the vibrations of the reed was supplied from two chambers filled with compressed air from air-pumps driven by the steam-engine used for the electric machines at the South Foreland; but in the horns or trumpets now in operation, caloric engines perform the work of filling the air-chambers with compressed air, being more easily and economically worked, and avoiding the danger attendant upon the use of steam. The horns set up at the South Foreland were tested as to their power and range in different conditions of wind and weather; they were tried one against the other, and against other kinds of instruments. Different pressures of air and different notes were tried, as well as high and low elevations above the sea.

The Siren.—This kind of instrument has been in use on the coasts of the United States for some years, and the one tried at the South Foreland was forwarded to England by the authorities in America through the kind intervention of Major Elliot, then Engineer Secretary to the Lighthouse Board of that country. Messrs. Brown, of Progress Works, New York, are the adapters of the siren principle for fog-signal-purposes, and the instrument sent to England was their manufacture. Plate XIII shows the siren and its associated trumpet. For producing the sound, instead of a vibrating reed, two discs are employed, one fixed, the other made to rotate, each disc having, as you see, radial slits exactly corresponding to each other. The fixed disc[2] is fastened across the throat of the trumpet, and the rotating[3] disc is placed before it. Upon this rotating disc a pressure of steam, of about 70 lbs. to the square inch, is forced; and each time that the two discs correspond, a puff of steam goes through the coinciding slits into the trumpet, and a rapid succession of these coincidences produces a rapid succession of blows upon the air in the trumpet, which gives rise to a sound of great power. The most effective rate of rotating the disc is found to be from 2,400 to 2,800 revolutions per minute, and this has to be effected by separate mechanism. The trumpet is of cast iron, and it is not necessary to regulate the rotations of the disc so as to be in unison with the trumpet, as is the case with the vibrating reed and the air-horn; if required, the instrument could be made to sound all the notes in an octave. The siren was tried in reference to its sound-range in various conditions of wind and weather, and in comparison with other instruments; it was sounded at different pressures of

[1] See Plate XIV, figs. C. and D.
[2] See Plate XIV, fig. A. [3] See Plate XIV, fig. B.

steam, and at different rates of rotation of the disc, thus producing different notes. It was tried pointed downwards, and sideways from the observer; and the effect of its sound without the 16 feet trumpet was also tested. Subsequently the Engineer to the Trinity House, Mr. James N. Douglass, has adapted the caloric engine for working the siren; and this, besides being less dangerous, and requiring no water, will, by reason of its simplicity, enable the apparatus to be managed by the lightkeepers in the employ of the Trinity House, and thus to be worked as efficiently and more economically than by a steam-engine.

In the Report of the United States Lighthouse Board for 1874, the relative power of these instruments is thus stated:—First class siren as 9; twelve-inch whistle as 7; and the first class Daboll trumpet as 4; while the expenditure is as follows:—

	Siren.	Whistle.	Trumpet.
Coals per hour	180 lbs.	60 lbs.	20 lbs.
Water per hour	126 galls.	40 galls.	None.

Guns.—With reference to guns I shall say very little, seeing that Major Maitland is to bring the subject before the Institution on the evening of Monday the 17th instant; but a brief allusion to the various guns made use of by us in our experiments is necessary. We were kindly supplied with a 13-inch mortar, an old fashioned long 18-pounder gun (similar to the guns now in actual use as fog-signal guns), and a $5\frac{1}{2}$-inch short cast-iron howitzer. These various guns were tried under different circumstances of wind and weather, with small and large charges of powder, and in comparison with the other sound-producers.

Observations and General Results.

Having thus briefly described the instruments used, we will now proceed to the consideration of the observations made, and the general results obtained therefrom. The observations were almost all made at sea, on board one of the yachts belonging to the Trinity House, the scene of operations being shown on the diagram on the wall, and there were always three, four. or more observers from the Trinity House present, and Dr. Tyndall was very rarely absent. These observations were carried on in all sorts of weather, so that the effect of the various meteorological conditions on sound-transmission might be thoroughly tested; and the same experiments were repeated again and again, in order to leave no room for doubt as to the conclusions arrived at. From the middle of May, all through the summer, up to the end of November, the trials were carried on at brief intervals; and in the thick foggy weather of February in last year they were again resumed for a short period.

In stating to you the results obtained from the investigation, in addition to my own experience, I shall avail myself largely of the

exceedingly valuable report made by Dr. Tyndall on the subject, and of a memorandum upon the whole subject made by Sir Frederick Arrow, the Deputy Master of the Trinity House, with the object of making practical use of the knowledge gained.

The objects of the investigation may be classed under two general headings (1), to determine which instruments yield the most effective sounds, and (2), to gain more knowledge as to the manner in which sound is propagated through the atmosphere, particularly during the existence of fog.

With regard to the instruments tried, to which I have already alluded, the results obtained may be thus stated.

Whistles.—I cannot now do better than quote from Sir F. Arrow's memorandum: "Throughout the trials, their marked inferiority to "the other instruments has been recorded. The American whistle "yielding a harsh roar, when close at hand was deafening; but its "sound failed to penetrate to any useful distance. The Canadian "whistle appears to have been better, but it also failed in general "effective power, although occasionally it was heard at great dis- "tances. As a rule, the whistles were behind the siren, trumpet, and "gun, and seem to have been more dependent than the other instru- "ments on exceptional atmospheric conditions for yielding their best "results. The general conclusion seems to be, therefore, that for "practical purposes the steam-whistles, as at present tried, are proved "to be advantageous as fog-signals."

This conclusion, I may say, is fully borne out by the trials. It may be that the all-round diffusiveness of the whistle-sound weakens it so much that there is not force enough to send the sound to any distance; certainly the noise close at hand is extremely distressing. The results claimed for steam-whistles in Canada and America were by no means obtained in our experiments from the Canadian and American representative whistles sent over here, but it is possible that the difference between the atmospheres of the North American coasts and our southern shores in some measure accounts for this. Under certain very favourable circumstances the Canadian whistle has been heard at great distances; but at such times it is probable that any sound of moderate power would have been audible at the same distance. The real test of a fog-signal is in regard to its ability to overcome obstructing influences; and in this respect all the whistles were far inferior to the other sound-producers, for which reason I have refrained from entering into details respecting their construction, &c.

American Lighthouse Board Report for 1874, thus reports upon the whistle. "The sound of the whistle is equally distributed hori- "zontally; and when the whistle is upright, in the ordinary position, "its sound is more distinct in a horizontal plane passing through the "whistle than above or below it."

Air-horns.—These instruments, generally speaking, proved themselves fairly efficient. They were certainly superior to the whistles; and, as Sir Frederick Arrow justly remarks, "the satisfactory per- "formance of the trumpets during the late trials fully justifies their "present employment." It seems to me, however, that there are

some objections to the trumpet being made of brass, and also to the necessity which exists for tuning the reed in unison with the trumpet. The use of a trumpet consists chiefly in concentrating the sound into a beam, and thus causing it to be projected through the air with greater force in any required direction. The brass trumpet no doubt does this to certain extent, but as the molecules of the metal are also set in vibration, sound appears to be given off from all parts of the external surface of the trumpet, so that although a very loud sound may be produced in the immediate neighbourhood of the instrument, it is open to doubt whether that sound is transmitted with force to any great distance, its strength being, so to speak, dissipated in the space close to its source. I venture to throw out this idea, and hope it will call forth some authoritative corroboration or contradiction. I would further observe in reference to the tuning of the reed, that there is no doubt it requires a skilled hand and a musical ear to do this properly; and in the event of a reed breaking or cracking (to which reeds are liable when subjected to great pressure) it is not at all likely that a light-keeper would be able to put in another reed and tune it to the proper note, which contingency might cause some inconvenience in the actual working of a fog-signal.

The Siren.—We now come to the instrument of which Dr. Tyndall says, that "it is beyond question the most powerful fog-signal which "has hitherto been tried in England. It is specially powerful when "local noises, such as those of wind, rigging, breaking waves, shore-"surf, and the rattle of pebbles have to be overcome. Its density, "quality, pitch, and penetration render it dominant over such noises "after all other signal sounds have succumbed."

If nothing else had been demonstrated in our lengthened investigation, it would alone have been a most satisfactory achievement to make known the transcendent power of this instrument over all others. Its superiority consists in its general effectiveness up to a certain point under all conditions of wind and weather. Dr. Tyndall says:—"What may with certainty be affirmed is, that in almost all cases the "siren, even on steamers with paddles going, may be relied on at a "distance of two miles; in the great majority of cases it may be relied "upon at a distance of three miles, and in the majority of cases at a "distance greater than three miles." No other instrument, not even the gun, has proved itself able to cope with obstructive influences so well as the siren. With regard to the objections which it seems to me may be preferred against the brass trumpet and its vibrating reed, I would here observe that the trumpet of the siren is of cast iron, and does not take up the vibrations caused by the rapidly succeeding puffs of steam passing through the two discs. The whole of the sound produced is condensed in the siren trumpet, and sent out with great force in a more or less continuous but ever-widening beam. In our trials, the sound was invariably observed to be most effective when we were in the line of the axis of the trumpet. No tuning is required for this instrument; it is simply necessary to make the rotating disc revolve something over 2,000 times a minute by a simple mechanical arrange-

ment. In the experiments, steam alone was used for sounding the siren; but recently it has been successfully tried with compressed air. Mr. Douglass, the Trinity-House Engineer, having arranged for the requisite pressure of air being supplied by a large caloric engine, the results, as compared with those given by an equal pressure of steam, proved that there was little or no difference between them. It will therefore be practicable to establish powerful fog-signals on the siren principle at many places where steam would not have been available.

Guns.—Of the three kinds of gun tried at the South Foreland, the short cast iron $5\frac{1}{2}$-inch howitzer, with a 3 lb. charge of powder, certainly proved itself the best. One of the advantages of a gun report is its distinctive sound; but, under present arrangements, the duration of the sound is so short that it is liable to be obliterated by local noises, and is not easily picked up unless the observer is very close to the gun. The prolonged blast of the siren stands a far better chance of being heard than the short and sudden report of a gun. This consideration has induced the Corporation of the Trinity House to seek the assistance of the War Department in the construction of a special form of gun for fog-signal purposes, which will obviate some of the disadvantages to which the ordinary gun is liable. I need not say that the War Department responded most willingly to the request of the Trinity House; and on the evening of the 17th instant we shall have the great pleasure of hearing Major Maitland state how far they have gone in the matter. Under these circumstances, I need not pursue the question of guns any further.

From the foregoing remarks it will be seen that the siren stands out unmistakeably as the most efficient instrument for coast fog-signals known at the present time. This then concludes the first division of our observations; and I now will proceed to give you the details of the knowledge gained in regard to the propagation of sound through the atmosphere, specially with reference to making sound-signals in fog.

This portion of my subject relates essentially to a matter of scientific demonstration, and I must therefore draw my inspiration almost entirely from the Report of Dr. Tyndall, which gives the results of his persevering and learned researches.

For the sake of convenience I shall endeavour to put before you the results obtained under different headings; and in doing so it will be seen that the various meteorological conditions will be dealt with at the same time.

Fluctuation of Sound.—Almost the first noteworthy circumstance observed during the investigation, was that, independently of wind or weather, the sound range of the different signals varied considerably from day to day. Dr. Tyndall remarks, with reference to the observations made from 19th May to 2nd July:—

"In the foregoing observations we have had very remarkable "fluctuations in the range of the sound, that range varying from "three or four miles on May 19, to $10\frac{1}{2}$ or $12\frac{3}{4}$ miles on the 1st of "July. The direction and force of the wind, known to exercise a "potent influence upon sound, entirely fail to account for these

"fluctuations, nor could any other observed meteorological element "be held responsible for them."

On two days, apparently alike in respect of wind and weather, the sound-range would vary in an unaccountable manner. These astonishing results could only be referred to invisible differences in the atmosphere, which Dr. Tyndall thus explains:—

"Thus each succeeding day provided us with a virtually new "atmosphere; clearly showing that conclusions founded upon one "day's observations might utterly break down in the presence of the "phenomena of another day. This was most impressively demon- "strated on the day now to be referred to. The acoustic imperviousness of the 3rd of July was found to be still greater than that of "the 2nd, while the optical purity of the day was sensibly perfect. "The cliffs of the Foreland could be seen to-day at ten times the distance at which they ceased to be visible on the 1st, while the sounds "were cut off at one-sixth of the distance. At 2 P.M. neither guns "nor trumpets were able to pierce the transparent air to a depth of "three, hardly to a depth of two miles. This extraordinary opacity "was proved to arise from the irregular admixture with the air, of "the aqueous vapour raised by a powerful sun. This vapour, though "perfectly invisible, produced what I have called an acoustic cloud "impervious to the sound, and from which the sound-waves were "thrown back as the waves of light are from an ordinary cloud."

The importance of the knowledge gained as to the fluctuation of the sound-range on different days will be evident to all present from the following further remarks of Dr. Tyndall:

"In a report written for the Trinity House on the subject of fog- "signals, my excellent predecessor, Professor Faraday, expresses the "opinion that a false promise to the mariner would be worse than no "promise at all. Casting our eyes back upon the observations here "recorded, we find the sound-range on clear, calm days varying from "$2\frac{1}{2}$ miles to $16\frac{1}{2}$ miles. It must be evident that an instruction "founded on the latter observation would be fraught with peril in "weather corresponding to the former. Not the maximum but the "minimum sound-range should be impressed upon the mariner. "Want of attention to this point may be followed by disastrous "consequences."

General Duane, in the Report of the United States Lighthouse Board, 1874, thus reports:—"From an attentive observation during "three years of the fog-signals on this coast, and from reports re- "ceived from captains and pilots, I am convinced that in some con- "ditions of the atmosphere the most powerful signals will be at times "unreliable."

This view entirely coincides with that always followed by the Trinity House in all matters relating to coast marking; they endeavour to give the mariner information upon which he can depend, and refrain altogether from publishing statements which are merely "probable." The siren, however, of all the instruments, proved itself to be the best able to cope with this obstructive influence, and as, I have before observed, may be relied on under any circumstances

at a distance of two miles, and in the majority of cases at a distance of three miles, therefore to that extent the fluctuation of the sound may be obviated by the use of the siren.

Aërial Echoes.—The obstruction of sound by the irregular distribution of invisible aqueous vapour in the atmosphere has, as Dr. Tyndall observes, its complementary side. The question is, what becomes of the mass of sound so impeded? It seemed incredible that a great body of sound should be utterly annihilated in the short space of three miles, when on other occasions the same force of sound had travelled $16\frac{3}{4}$ miles. Was it wasted entirely, or could it have been reflected back? The proof was at hand, and here is Dr. Tyndall's description of it, he having gone ashore at the Foreland and landed at the base of the cliff:

"The body of air which had already shown such extraordinary "power to intercept the sound, and which manifested this power still "more impressively later in the day, was now in front of us. On "it the sonorous waves impinged, and from it they were sent back to "us with astonishing intensity. The instruments, hidden from view, "were on the summit of a cliff 235 feet above us, the sea was smooth "and clear of ships, the atmosphere was without a cloud, and there "was no object in sight which could possibly produce the observed "effect. From the perfectly transparent air the echoes came, at first "with a strength apparently but little less than that of the direct "sound, and then dying gradually and continuously away: the echoes "reached us, as if by magic, from absolutely invisible walls."

This, therefore, was a striking and most satisfactory corroboration of the theory formed by Dr. Tyndall as to the aërial obstruction of sound. Further, in reference to the subject, the Professor remarks, "Whatever might be the state of the weather—cloudy, serene, stormy, "or calm, the aërial echoes, though varying in strength and duration "from day to day, were never absent, and on many days under a per- "fectly clear sky they reached (in the case of the siren) an astonish- "ing intensity."

Effect of Wind upon Sound Transmission.—Throughout the trials, adverse winds proved to be very potent in obstructing the passage of sound; this result is in accordance with general experience. But I may state that even against a wind of force 4 or 5, the sound of the siren is able to penetrate to a distance of about three miles, and would be of service to a mariner within that distance. No other instrument was able to cope so successfully with the opposing force of the wind. Happily thick fog is rarely accompanied by strong wind, and, therefore, the obstructive power of the latter element is not likely to be brought into play at times when a fog-signal would be generally serviceable. But it is a satisfactory result of the trials, to be assured that in thick, rainy, windy weather, when a sound-signal would be of great value, the siren will convey a warning to the sailor at more than two miles distance from the danger the signal is intended to mark. It was found that when the siren was pointed to windward and the whole strength of the sound projected right against the opposing force of the wind, it gave the most satisfactory results,

the wind carrying the sound effectually to the leeward part of the arc required to be guarded: this pointing to windward will therefore be always adopted in future. Whilst upon this subject, I may add that the passage of sound across the wind was not found to be impeded to any great extent by the action of the wind.

In the Report of the United States Lighthouse Board, page 114, an instance is recorded in which the sound was lost in the eye of the wind at 5 miles, whereas with the wind it only reached $4\frac{1}{2}$ miles; velocity of wind by anemometer $10\frac{1}{2}$ miles per hour; and it is further stated that this is the only instance on record in which the sound has been heard further against than with the wind.

Effect of Rain, Hail, and Snow.—With regard to falling rain and hail, it was most clearly demonstrated that no obstruction is thereby offered to the passage of sound, but on the contrary, it was proved that the effect is rather to remove obstructions, as may be seen from the following quotations from Dr. Tyndall's report:—

"The heavy rain at length reached us, but although it was falling "all the way between us and the Foreland, the sound, instead of being "deadened, rose perceptibly in power. Hail was now added to the "rain, and the shower reached a tropical violence. The deck was "thickly covered with hailstones, which here and there floated upon "the rain water, the latter not having time to escape. In the midst "of this furious squall both the horn and the syren were distinctly "heard; and as the shower lightened, thus lessening the local noises, "the sounds so rose in power, that we heard them at a distance of $7\frac{1}{2}$ "miles, distinctly louder than they had been heard through the "rainless atmosphere at 5 miles."

I would remark that in every instance of falling rain during the experiments, the sounds were heard more plainly than on many fine clear days. This is an important addition to our knowledge in regard to the propagation of sound, for it had hitherto been the general opinion that falling rain had a stifling effect upon sound. As respects snow, Dr. Tyndall quotes his own experience in the Alps, to show that no interruption of the sound-wave is caused by snow showers.

Effect of Fog.—Previously to our experiments, it had been generally supposed that the effect of fog upon sound was to deaden it; certainly there existed but little real knowledge on the subject. The result of the experiments, however, made in the dense fogs of February, 1874, proved conclusively that fog does not impede the transmission of sound, but on the contrary, that a foggy atmosphere appears to be a highly favourable condition for the travelling of the sound-wave. In reference to this matter, Dr. Tyndall says:—

"The experiments thus far made are perfectly concurrent in in-"dicating that at the particular time when fog-signals are needed, "that is, during foggy weather, the air in which the fog is suspended "is in a highly homogeneous condition; hence it is in the highest "degree probable that in the case of fog we may rely upon these "signals being effective at much greater distances than those just "mentioned."

He adds a few words of scientific explanation as follows:—

"It is hardly necessary for me to say a word to guard myself "against the misconception that I consider sound to be assisted by "the fog itself. Fog I regard as the visible result of an act of con- "densation which removes the real barrier to transmission, that "barrier being aqueous vapour, so mixed with air as to render it "acoustically flocculent or turbid. The fog particles appear to have "no more influence upon the waves of sound than the suspended "matter stirred up over the banks of Newfoundland has upon the "waves of the Atlantic."

It is in the highest degree satisfactory to have this point solved so conclusively, for in regard to the whole question of signalling by means of sound in foggy weather, it shows us where we stand, and we know now that when light is rendered ineffectual by fog, we may trust to sound to carry on the important duty of signalling to the mariner.

In reference to the knowledge gained as to the effect of different meteorological conditions upon the transmission of sound through the atmosphere, I may remark that in many respects nautical men will find it of great value, independently of its connection with fog-signals. It is well known that in the practice of navigation not a little is done by means of sound—the use of speaking-trumpets for hailing; of gun-signals to indicate distress, &c.; of steam-whistles for signalling, is more or less common among merchant ships, and in the Royal Navy also a great deal is done by means of sound-signals. By the results now obtained, mariners will undoubtedly understand better how to make such signals effective, if they will give consideration to the influence exercised upon sound by the various atmospheric conditions. Here is a small and very effective horn which is used when fog comes on suddenly until the fog-signal is in proper working order. This instrument is really a good one, and should be used on board ship instead of the poor, weak instruments so often seen on board. Formerly this old bellows-horn was used, but the new instrument is a vast improvement, and therefore I think worthy of being brought to your notice. It is patented in America, and I think here also, by Mr. Anderson, the inventor.

Professor Henry, Chairman of the United States Lighthouse Board, thus reports on the fluctuation of sound at page 107 in the report for 1874:—

"The phenomena which had been observed at this and other stations "along the coast, consisted of great variation of intensity of sound "while approaching and receding from the station. The vessel was "approaching Whitehead from the south-westward, when at a distance "of about six miles from the station the fog-signal, which is a 10-inch "steam-whistle, was distinctly perceived, and continued to be heard "with increasing intensity of sound until within about three miles, "when the sound suddenly ceased to be heard, and was not perceived "again until the vessel approached within a quarter of a mile of the "station, although from conclusive evidence furnished by the keeper "it was shown that the signal had been sounding the whole time."

Positions for Coast Fog-Signals.—Sir Frederick Arrow in his

memorandum, says, with reference to the question as to the height above the sea at which a signal should be placed, that the results of the trials "show that it is advantageous that such signals should be "placed at a considerable height above the sea level, in order to avoid "the interference caused by the noise of waves breaking on the shore, "the rattle of pebbles, &c." This is an important consideration. But in connection with the selection of sites for fog-signals, it has also been shown to be necessary to take into account the possible effect of a sound-shadow, caused by the interference of a projecting point or cliff in the vicinity, on the passage of the sound over the entire area intended to be guarded. The effect of such a sound-shadow was experienced again and again in an experiment at the South Foreland. The Committee to America also made a recommendation to the same effect, and the recent investigations entirely bear out the opinion expressed by that Committee.

Whilst touching upon this subject of positions for fog-signals, I think it well again to quote from the valuable memorandum of Sir Frederick Arrow, in reference to another important point. His opinion is, "That no signal should be required to mark dangers ex- "tending seaward, more than a mile or a mile and a quarter. The "minimum effective range of a signal being $2\frac{1}{2}$ miles; vessels "approaching such dangers and coming into the sound-range, would "have room to manœuvre, and be able to keep at a safe distance." These various questions, in relation to choosing the positions for fog-signals, have a very important bearing on the practical work of establishing such signals, and the views expressed will be of great service in assisting the Trinity House in their selection of new sites.

Distinctive Sounds.—The next point with which I have to deal, is also one of the greatest importance, viz., the question of distinctions between adjacent signals. It would not do for all signals to be sounding alike, at least, not if the sound-signal is intended to perform the duty of a light which is obscured, the character of which may be fixed, revolving, or what not, and which should indicate to the mariner where he is. It is necessary, therefore, to diversify the signals, but at the same time it is imperative that the utmost simplicity be followed in any distinctions which may be adopted. In the experiments, it was found that the sounds of the whistle, horn, and siren, though differing slightly, resembled each other so much that it was only by the nicest discrimination that any difference was appreciated; indeed, Sir Frederick Arrow very justly remarks that "the siren, horns, and whistles, have "invariably been spoken of by sailors in the vicinity as the fog- "horns," and they failed altogether to appreciate any difference between the sounds. For purposes of distinction, therefore, the variation of the length of the silent interval between the blasts of a siren will, it is hoped, prove efficacious, provided the distinctions are of the most simple and intelligible description. Anything complicated, requiring careful and trained observation, will be out of the question. It is in this respect that hopes are entertained of the gun being made valuable. Between the sound of a gun-report, and that of a siren-

blast there is a perfectly intelligible difference, which the most ordinary intelligence would understand. I am, however, of opinion that something satisfactory may be achieved by combinations of sounds differing greatly from each other. In the case of the siren, for instance, which could be adapted for such an arrangement, it would be quite possible to sound two distinct notes in tolerably quick succession, say a high note followed by a bass one. The contrast would sufficiently indicate itself, and be a perfectly intelligible distinction. I do not believe it would be of any use for distinctive purposes to have a signal of one note at one station, and one with a different note at another, in the expectation that sailors would understand and guide themselves by the distinctiveness of each sound; but I do think that the direct contrast of two notes could not fail to be understood, and thus be made to convey to the mariner the information as to what signal it was he heard. I guard myself against recommending any elaborate system of distinctions for sound-signals, but I am of opinion that this notion of contrasts may be further developed without introducing complications. It might be possible also to have a gun-report and a siren-blast placed in direct contrast; this again, I believe, would provide an adequate distinctiveness. The subject is one which experience will develope; and in pointing out the present condition of this branch of my subject, I have also stated my own views as to what may be achieved in this respect.

Conclusion.—I now come to the end of my subject, having put before you what I consider the various points of interest and importance connected with the protracted investigation in which I had the honour to be engaged; and in concluding my paper, I feel that I cannot do better than quote the admirable remarks of Sir Frederick Arrow on this great question. He says, "The subject of fog-signals "has by means of this investigation received a great impetus; it may "fairly be said that we have taken a considerable step in advance, "and it only remains to follow it up. As we go forward, our ex- "perience will widen, and although it is more than probable that "a few years of practical experience and testing of fog-signals "will materially modify our present views, and improve considerably "the instruments we have, yet we know now how to go forward, and "in what direction to bend our efforts. It is to be hoped that before "very long our coasts will be guarded by a complete chain of sound- "signals, all effective and useful to the mariner. * * It is almost "unnecessary to add that in thus giving practical effect to the spirit "of the recommendations of this valuable report, the Elder Brethren "will have the satisfaction of knowing they are acting in the highest "interests of humanity, and conferring an inestimable boon on the "nautical community at large."

To this I would add that, in accordance with the recommendations, the Trinity House have already arranged for the placing of no less than twenty new fog-signals on our coasts, the works for which are now in hand; and these when completed will be succeeded by others, so that in a very short time our coasts will be surrounded by a complete chain of fog-signals. Thus are the Trinity House making

practical use of the results obtained from their recent experiments in relation to fog-signals.

Finally, I have to express my very great obligations to Sir Frederick Arrow, and to Dr. Tyndall, for a considerable part of the material of my lecture. Both gentlemen have most cheerfully given me free permission to make use of their reports, and I need hardly say that the assistance thus derived has been of the greatest service to me, and I trust of interest to you. I am also much indebted to Mr. E. P. Edwards, of the Trinity House, for the assistance he has given me in preparing this report. The whole subject has been dealt with in a most persevering and masterly manner by Dr. Tyndall; and for his self-sacrificing labours not only the Trinity House, but the world at large, owes him a debt of gratitude. I would he had been here in my place to describe to you in his own brilliant and lucid style what I have attempted to put before you in so imperfect a manner.

Evening Meeting.

Monday, May 17th, 1875.

MAJOR-GENERAL F. M. EARDLEY-WILMOT, R.A., F.R.S., in the Chair.

NAMES of MEMBERS who joined the Institution between the 4th and 17th May, 1875.

LIFE.

Taylor, A. H., Captain 21st Hussars.
Wingfield, C. G. L., Lieut. 54th Regiment.
Troyte, John Edwd., Lieut. 4th King's Own Regt.
Harmar, C. D. O., Lieut. 39th Regt.
Perrott, Herbert C., Lieut. East Kent Militia.

ANNUAL.

Meurant, Edwd., Major 83rd Regt.
Macpherson, Jas. F., Captain and Adjutant Border Rifles.
Scriven, A. G., Lieut. 52nd Regt.
Parkinson, C. F., Major 95th Regt.
Robinson, H. A., Captain 16th Lancers.
Wilkinson, G. A., Lieut.-Col. R.H.A.

FOG-SIGNALLING BY EXPLOSIVES.

By Major MAITLAND, R.A., Assistant-Superintendent, Royal Gun-Factory, Woolwich.

ON Friday week Admiral Collinson read a paper in this theatre which was listenedto with great interest, on the general subject of "Fog-Signals." He described fully certain experiments which were carried on in 1873 at the South Foreland by the Trinity Board, under the watchful care of Professor Tyndall. He explained that under some conditions of the atmosphere the sounds produced by horns, whistles, and notably by the siren, penetrated the distance more successfully than those of guns; while, under other conditions, the dull thud of an explosion made itself heard when all other sounds were stilled. The note of the most powerful instrument yet tried—the siren—resembles a harsh, prolonged scream, and thus is less likely to be annulled by a puff of wind or a local disturbance than the very brief sound of a gun; on the other hand, the latter sound, when heard, is less likely to be mistaken or overlooked, for, as most of those present have probably experienced, the report of a piece provokes instant attention.

The Elder Brethren of the Trinity Board therefore conceived the idea of differentiating the signals, by placing sirens on board light-ships and guns on shore stations, so that the befogged mariner might be able to tell approximately what part of the coast was near him.

Admiral Collinson explained also that on different days the atmosphere varied greatly, so much so that sounds audible up to 15 miles one day were lost at 3 miles on another. This irregularity affected all sounds in about equal degrees.

Three kinds of guns were tried during the experiments, all were of cast-iron, one being an 18-pr. gun, one a 24-pr. howitzer, and one a

13-inch mortar. Each was fired with a charge of 3 lbs. of powder and a junk wad, and the 24-pr. howitzer proved clearly the most efficient. During a long-continued fog it was found that two men serving the gun could not keep up the firing more rapidly than at the rate of one discharge in a quarter of an hour; this interval was too long. A ship might readily run into great peril in the time, especially if she chanced to miss hearing but one signal. It was therefore thought desirable to curtail this period to five minutes at the most. Affairs stood thus when the Trinity Board decided to apply to the War Office for a solution of the following problem:—

To produce the most far-reaching sound possible with a charge of 3 lbs. of powder, and to enable two men to keep up the firing at intervals of not more than five minutes during a long-continued fog.

The matter was referred to Colonel Campbell, R.A., Superintendent of the Royal Gun Factory, whose assistant I have the honour to be; hence I have been asked to give you a brief account of the experiments which have been carried on at the Royal Arsenal to determine the solution of the above question.

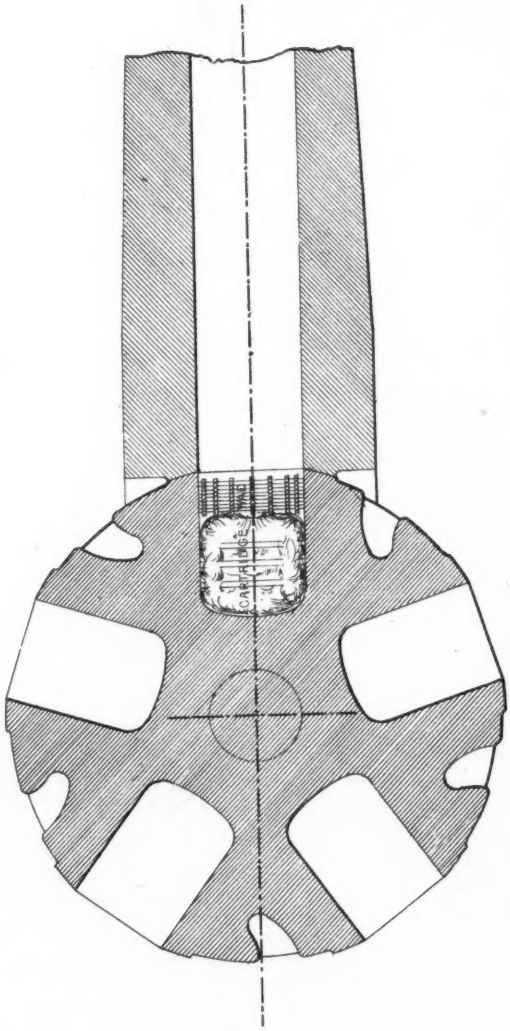
The problem divides itself into two parts,—ease of working and propulsion of sound. We will take ease of working first. The principal part of the labour consists in sponging out and ramming home. When blank cartridge is fired it sometimes happens that a piece of the serge is left behind, smouldering in the bore, and this may ignite the fresh cartridge prematurely; therefore, sponging out has to be carefully performed. To avoid the labour consequent on these two operations, a machine—it can scarcely be called a gun—was devised in the Royal Gun Factory. (See Pl. xv.) The fore part consists of a barrel open at both ends, the interior diameter being 5 inches and the length 21 inches. The breech end of the barrel abuts in a close-fitting joint against the mouth of a chamber, formed in a horizontal wheel containing five chambers. This wheel revolves on two vertical trunnions. The chambers are 7 inches in depth, and, like the barrel, 5 inches in diameter. The trunnions fit into bars, which are a continuation of the barrel, and by means of powerful screws in rear, the wheel can be pressed as close against the barrel as necessary. The joint is closed with a ring of steel, somewhat on the principle of the throat-valve of a hydraulic press.

A passage communicates through the top of the breech-carrier with the rear of the chamber next the barrel. This passage is so arranged, by means of a catch-spring, that the communication is interrupted except when a chamber is exactly fitted to the barrel, and then only can the gun be fired. This is accomplished by means of an ordinary tube dropped into the passage.

Since there are five chambers round the wheel, each is used only once in five reports; and supposing five minutes to elapse between the reports, each chamber will be used but once in 25 minutes, and thus no smouldering fragment can ignite the succeeding cartridge.

The gunner wheels up a covered barrow, containing a supply of cartridges, to the left side of the gun, with the left hand places one in the chamber next to be fired, and with the right hand turns the wheel,

SKETCH OF GENERAL IDEA OF PROPOSED BREECH LOADING SIGNAL GUN.



J. Jobbins

which locks itself in the required position. He then drops a tube into the vent passage, and fires. No ramming home or sponging out are required.

The design has met with the approval of the Elder Brethren and their scientific advisers, and probably will ere long be put to the test of actual trial. Of course a method of this sort would be quite unadapted for warfare, being constructed merely to fire blank cartridge, which causes comparatively low pressure on the metal.

We now come to a much more difficult question, that of the propulsion of sound. The designing of a gun is a simple problem, and one which falls into the routine of every-day work; but the production of sound is quite another matter. We have hitherto looked upon the noise of a discharge as a necessary evil, and have altogether neglected it. What, then, have we to go upon? What is the cause of the report of a gun? Clearly the sound is made up of two factors, as was indeed pointed out by Professor Tyndall in his comments on the design I have just shown you. One factor is the blow struck by the expanding gas on the still air, the other is the vibration of the metal of the gun. Bronze guns have always been considered more trying to the ears of artillerymen than iron ones, and it was thought that the sonorous qualities of the metal would be of value in sound-propelling; hence the gun, whose design I have explained, was intended to be made of bronze. Professor Tyndall, however, at once surmised that the advantage thus gained would disappear as the distance of the listener increased, and he proposed to cheapen the apparatus by employing cast-iron.

It is found that when a gun is fired, if a line be drawn across the muzzle at right angles, a great difference in the intensity of the sound is experienced by the observer, according to whether he places himself a little before or behind this line. Any one can readily convince himself of this fact by going to Shoeburyness when 38-ton guns are being fired. I think it probable that the first trial in front will amply satisfy him. It would appear, then, that the rapidly expanding gas strikes a violent blow on the air in front of the muzzle, and, failing to drive the mass away at once, sends its vibrations forcibly out on all sides. The state of the ground under the muzzle when heavy guns are fired confirms this view.

Now, sound, as you are aware, is propagated by alternate compression and expansion in the direction in which it is travelling; light, on the other hand, vibrates at right angles to the ray: nevertheless, it is found that sound behaves like light in many ways. Thus, if a wave of sound impinge on a flat surface at any angle it will be reflected at the same angle. This property is of great value to the fog-signaller; a simple experiment will suffice to illustrate it. Place two tubes to form an angle like the letter V, and fix a flat surface at the point; a sound travelling through one tube will be reflected through the other if the flat surface be placed at the proper angle.

In order to catch the vibrations passing to the sides of the muzzle, it was proposed to enlarge the mouth of the gun into the form of a wide-spreading cup. It is not easy to ascertain precisely the distance

in front of the muzzle at which the expanding gas strikes with the greatest force, but it is tolerably clear that when once this point is ascertained it may be made the focus of a parabola. This curve possesses the property of propelling reflections in parallel lines straight forward when any part of it is struck from the focus. (Pl. xvi.)

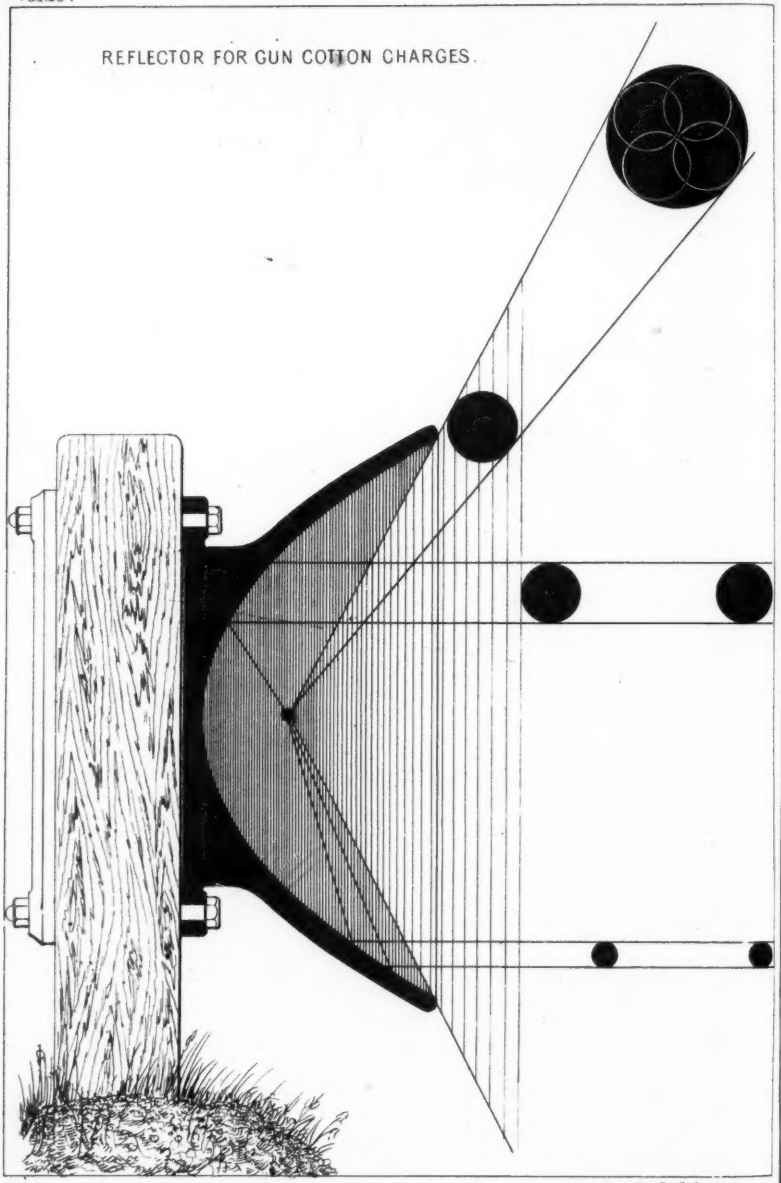
Now, as is well known, most forces, such as attraction, heat, sound, act in proportion to the inverse squares of their distances. If the sun were at half its present distance from us it would give us four times as much heat; if at one-third of its distance, it would give us nine times as much heat. Thus, when a sound is originated, it propagates its vibrations in all directions equally. If it starts in the centre of a hollow sphere it will strike all parts of the interior surface with equal force. Substitute a hollow sphere whose diameter is twice that of the first and the sound will still strike all parts equally, but will be diffused over a surface four times as large, and therefore each square inch of the interior surface of the large sphere will receive only one-fourth of the sound impinging on each square inch of the small sphere. I trust I may be pardoned for introducing such elementary considerations, as it is safest to be quite clear on so important a point.

Now, observe what takes place when sound is generated in the focus of a parabola. (Pl. xvi.) It radiates at first in all directions. You see two diverging rays passing out of the front of the reflector; the effect of these follows the law of inverse squares just alluded to, but the other rays which strike the curve are reflected in parallel lines, and the space they cover remains constant whatever the distance may be. From this it appears that if a sound be generated accurately in the focus of a parabola the reflected portion will travel to any distance unimpaired, if no disturbing cause exist. As a matter of fact, since the focus is a mere point no sound-producer can accurately occupy it, and a certain amount of dispersion will always take place; also the atmosphere absorbs and reflects a portion of the vibrations. The result of these actions is that the loss of power, instead of varying with the square of the distance, varies approximately with the first power of the distance. That is, while a sound produced in the open has but one-fourth of the power at two miles that it has at one mile, a sound produced in the focus of a parabola has about one-half, and thus the force is taken from behind, from the sides, from above, from below, where it is not wanted, and is propelled in the most desirable direction.

I have here two parabolas, exactly of the same size and form. In the focus of one is placed the root of the sensitive flame. You see that the crumpling of a piece of paper is sufficient to excite the flame. I increase the distance, the agitation lessens till, at about 10 feet, the flame becomes quiet. The other parabola is then brought up facing the flame, and as soon as the focus coincides with the sound-producing paper the flame dances once more.

Mr. Douglas, Engineer to the Trinity Board, made some trials at the South Foreland, with a fowling-piece placed in the mouth of the siren, which somewhat resembled a cone, and finding that a considerable improvement resulted, he expressed a wish that this kind of mouth should be tried. Accordingly some preliminary experiments were

REFLECTOR FOR GUN COTTON CHARGES.



J Jobbins

carried out at the proof butt at Woolwich Arsenal, and I have laid on the table the instruments which were actually tested.

There are two other points in designing a gun to produce the greatest possible noise with a given charge to which I must now allude. These are the diameter and the length of the bore. As the sound is occasioned by the blow of the expanded gas on the air, the more sudden we can make this blow the louder will be the sound. It becomes an object, then, to cause the powder to burn up as rapidly as possible; for this purpose the grain must be small, so as to consume quickly, and the shape of the charge should approach that of a sphere. The former condition is fairly satisfied by the "large grain" (L.G.) powder of the service, the much abused *poudre brutale*, which is the smallest used for guns, having been termed "large grain" in comparison with the "fine grain" used for small arms before the enlarged modern powders were introduced. The latter condition is arrived at for 3 lb. of powder by making the bore of the gun 5 inches in diameter, the cartridge will then be 5 inches long as well as 5 inches thick.

So much for the calibre of the gun—next for the length. It is desirable that the powder should be all burnt up before leaving the bore. A wad is, therefore, added of sufficient mass to prevent the foremost grains of the quick-burning powder from being driven out unburnt. It will be in the recollection of many, how blank charges of the slow-burning pebble powder peppered a yacht when the Shah was present at a naval review at Portsmouth. The bore of the gun should be of sufficient length to allow of the thorough consumption of the powder; but on the other hand, if too long, the elasticity of the column of air in the gun will deaden the blow—the metal will absorb the vibrations—and the whole beneficial effect will be lessened. The happy mean appears to be between 5 and 6 calibres, that is, the bore should be 5 or 6 times as long as it is broad. A slow burning powder, exploded in a bore of too great length, gives a certain *woolliness* to the sound, which is less effective than a sharp clear report.

I took an opportunity, a few days ago, of firing 60 lbs. of powder (R.L.G.) in a 38-ton gun, fitted with crusher gauges for taking the pressures in the bore.[1] A wad, which was not as stiff as it should have been, was placed in front of the cartridge, whose breadth and length were nearly equal. The curve indicating the pressure may be traced from these data:—

At the end of the bore, pressure	. .	·76 tons
At 1 ft. from end	. . . . .	4·63 ,,
At 2 ft. ,,	. . . . .	2·36 ,,
At 3 ft. ,,	. . . . .	1·84 ,,
At 4 ft. ,,	. . . . .	·40 ,,
At 5 ft. ,,	. . . . .	about ·20 ,,

showing that all the work of the powder is practically accomplished at this distance, and confirming the advantage obtained by a length of between 5 and 6 diameters.

I will now describe the experiments which have been carried on at the proof butt, in the Arsenal.

[1] The calibre of the 38-ton gun is 12·5 inches.

Four guns were first tested, viz.:—

No. 1. Cast iron, with plain muzzle.
No. 2. „ with small cone mouth.
No. 3. Bronze, shallow parabolic mouth.
No. 4. Cast iron „ „

They were all precisely similar with respect to charge, length of bore, and calibre; these elements being in accordance with the principles on which I have already dilated. They were fired in a succession of series, and the loudness of their reports was numerically estimated by a party of observers, who increased their distance from the guns at each series, starting from 100 yards and ending at 3,000 yards. A second experiment was then carried out in the same way, except that the observers remained at the longest distance (3,000 yards) all the while. The order of firing was varied, so that no one knew at the time which report he was estimating, and thus poor fallible human nature had no chance of fudging.

The observations, of course, were somewhat obscured by the occurrence of puffs of wind, by the difficulty of estimating minute differences, and by the effect of local noises, but the grand principle of averages came to our aid, and helped us to some valuable results. The method adopted was a simple one: on reducing every man's observations it was found that there was pretty general agreement though not a perfect one. Thus in the first experiment seven out of eight observers placed the small cone first; the eighth placed it third. Adding together these numbers, the total is ten, which gives a mean of 1·25, and this may be called the figure of merit. The lower the figure the better the gun. The cast-iron plain muzzle came out thus:—

4th.	3rd.	2nd.	4th.	4th.	3rd or 4th.	2nd.	4th.

giving a total of 26·5—mean 3·31.

The cast parabola and the bronze parabola were represented respectively by 2·62 and 2·81.

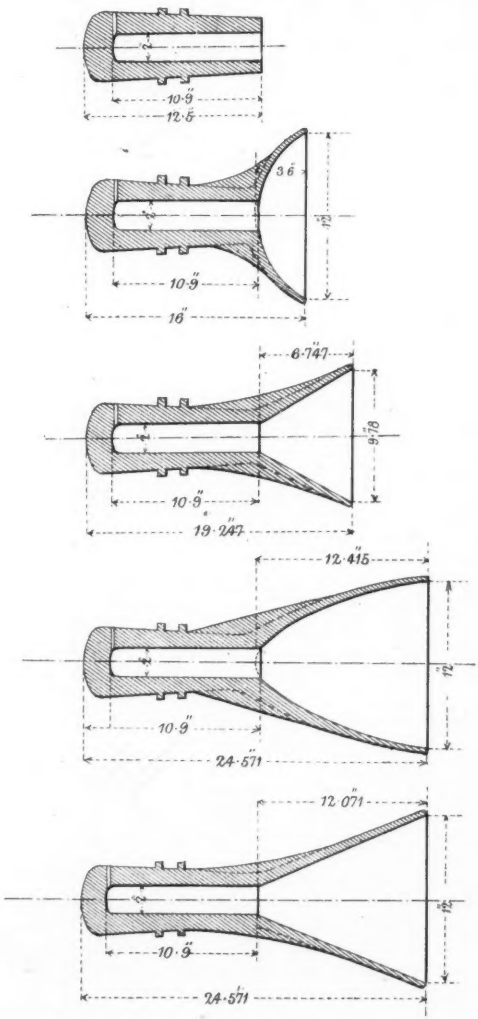
Thus, at the variable distances, the cone was unmistakeably best, and the plain gun worst, while the cast iron parabola slightly beat the bronze one. Turning to the second experiment, where the observers were stationed entirely at the long range, the figures came out thus:—

Cast iron cone	1·00
„ parabola	2·08
Bronze „	3·16
Cast iron plain gun	3·71

The cone was first in every ones estimation, and thus maintained a clear superiority. The general order was preserved, confirming the result of the first experiment. It was evident, however, that the cast-iron parabola had gained, while the bronze parabola had lost. This led at once to the idea that distance was unfavourable to bronze, and the observations of the first experiment were accordingly summed up to 1,000 yards only. The result was that the cone was still first, the

SMALL GUNS USED IN THE EXPERIMENTS AT WOOLWICH.

Scale 1 Inch = 1 Foot.



J. Jobbins

bronze parabola was second, the plain gun third, and the cast iron parabola last. This confirmed our suspicions, and showed that Professor Tyndall was quite right in his opinion that any advantage gained by the sonorous qualities of bronze would disappear with increase of distance. It also tended to show that bronze was at a positive disadvantage in this respect when compared with cast iron. It must be remembered that the guns were fired horizontally from the top of the butt in the Arsenal, and for the short ranges up to 1,000 yards, the observers were rather below their level. The parabolas then sent their maximum sound over the listeners' heads, but the resonance of the bronze told at short ranges, and enabled it to beat its fellow parabola and the plain gun. The cone did not collect the sound sufficiently to miss the observers, and therefore beat all the other guns. It has a great advantage over the shallow parabolas in depth.

Professor Abel, Chemist to the War Department, who, though not the inventor of guncotton, may yet be called its stepfather, had conceived the idea that this material would prove more effective as a sound-producer than gunpowder. If it is correct to assume that rapidity of ignition and violence of shock are really the sound-producing qualities, it might certainly be expected that this explosive would be highly successful. Its rapidity of detonation in the open air and in a wet condition reaches 20,000 feet per second. The explosion of powder cannot be compared to it. Guncotton requires no gun to fire it from; can be kept saturated with moisture, so that a red-hot poker will not burn it, and yet in this safe state can be detonated by the addition of a small primer of dry guncotton. Practice would soon accustom the operator to explode charges with certainty, and with little labour; and there is no doubt that its use offers many advantages. The drawback is the price.

In the first trials of sound-producers, 8 ounces of wet guncotton were detonated by 2 ounces of dry material. Thus, a charge of 10 ounces of guncotton was pitted against one of 4 ounces of powder, and as guncotton is at present just three times as expensive as powder no comparison of value could be made. As a matter of fact, the guncotton gave very superior results, as was to be expected, but it was impossible to estimate how far superior. It was therefore determined to include guncotton in the next series of experiments on more definite terms, and in February last the following trials were carried out, Mr. Abel superintending the arrangements for firing the guncotton.

The general arrangements were the same as previously described. Six sound-producers were compared at varying ranges, and also at a constant long range.

No. 1. Cast iron plain gun as before (this gun forms a starting point, representing the ordinary type of howitzer used in the service).

No. 2. Cast iron large cone, new.

No. 3. Cast iron small cone, old.

No. 4. Cast iron parabola, new, having axis and width of mouth equal to those of the large cone No. 2.

No. 5. Guncotton detonated in the focus of a parabolic reflector.

No. 6. Guncotton detonated in the open air.

All the charges, whether of powder or gun cotton, weighed four ounces.

A party of observers estimated the intensity of the reports at ranges varying from 100 to 4,400 yards, and on reducing their records the figures of merit came out as shown in the table:—

No. 1. Plain gun	5·82
No. 2. Large cone	3·71
No. 3. Small cone	4·00
No. 4. Parabola	4·41
No. 5. Guncotton in reflector	1·00
No. 6. Guncotton in open	2·00

The guncotton in a parabolic reflector exhibits an unmistakeable superiority, while the guncotton unconfined is clearly the next best. Of the guns all the specially constructed mouths beat the plain muzzle; the large cone is slightly superior to the small one, which is a little better than the parabola.

Twelve observers next stationed themselves at about 5,000 yards distance. The reduced results were as follows:—

No. 1. Plain gun	5·00
No. 2. Large cone	5·50
No. 3. Small cone	4·33
No. 4. Parabola	3·17
No. 5. Guncotton in reflector	1·00
No. 6. Guncotton in open	2·00

The guncotton charges confirm the previous result, but the order of the guns has now changed. The parabola has risen to the first place, the small cone comes second, while the plain gun and the large cone bring up the rear, the latter being slightly the worst.

Returning to the first experiment and dividing it into two parts, viz., from 100 to 1,600 yards, and from 1,900 to 4,400 yards, we obtain the following results:—

	100 to 1,600 yards.	1,900 to 4,400 yards.
No. 1. Plain gun	4·82	5.55
No. 2. Large cone	4·27	4·00
No. 3. Small cone	3·64	4·86
No. 4. Parabola	5·27	3·59
No. 5. Guncotton in reflector	1·00	1·00
No. 6. Guncotton in open	2·00	2·00

Thus it appears that at all ranges and in every observer's judgment, the guncotton in a reflector is the best, and the guncotton in the open next best; and it may now, I think, be assumed as a fact that when equal weights are employed, guncotton yields a decidedly louder report than powder, while the addition of a parabolic reflector confers a clear seupriority.

The tale told by the guns has more variety of incident. At the shorter ranges near the butt, where the axes of the guns point over the heads of the observers, the parabola is beaten by all, even the plain gun, confirming the result arrived at in the first experiments of

November with the shallow cast iron parabola. As the distance increases, the sound, not having proceeded accurately from the focus, and being moreover somewhat dispersed by the air, spreads out, but much less widely than in the case of the cones, or still more of the plain gun, till the power thus husbanded begins to tell at the long ranges, and gives the parabola an easy victory. The two cones are on the whole nearly equal, and their variations are probably due to the natural errors of the experiment.

In these two trials, equal weights of guncotton and powder were compared on a small scale. In the third experiment, now to be described, equal prices were compared on a large scale. One pound of guncotton was detonated in the open, and charges of three pounds of powder were fired from a 24-pounder howitzer of iron, a 12-pounder howitzer of bronze, and an 18-pounder gun of iron. A charge of 1½ lb. of guncotton was also detonated for comparison, in case this material should offer any important advantages in use, or should become cheaper.

The 24-pounder howitzer gave the best results; next came the 1½ lb. of guncotton, followed very closely by the 1 lb. of guncotton; while the bronze howitzer beat the 18-pounder gun. This experiment was of great importance, the series fired were but few, the results were rendered somewhat doubtful by local noises and gusts of wind, and it was therefore thought desirable to repeat it on a more extended scale.

This was done on the 2nd of May. The day was warm and bright, rain had fallen previously, and the air was moist. The wind was due south, a gentle breeze of fair steadiness nearly dead against the sound. The guns were N.N.E. of the observers, who, eight in number, stationed themselves at a distance of 2½ miles, in a position free from local noises. Owing to this cause, and to the favourable nature of the day, the concord between the observations was greater than on previous occasions. Seventeen series were fired, and the results of this experiment are entitled to much weight.

The figures of merit come out thus:—

No. 1.	Bronze 12-pounder howr. 3 lbs. L. G. Powder .	1·25
No. 2.	Cast iron 24-pounder ,, ,, .	2·31
No. 3.	,, 18-pounder gun. ,, .	2·69
No. 4.	Guncotton in open. 1 lb.	4·25
No. 5.	,, 1½ lb.	4·50

Thus it appears that all three guns beat the guncotton charges easily, that both the howitzers beat the 18-pounder gun, that the bronze howitzer beat the cast iron one, and that the guncotton charges were practically equal, whether of one, or of one and a half pound weight.

The superiority evinced by the guns firing powder charges equal in price to the guncotton was marked, and it was noticed during the experiment that more difference existed between the reports than had been observed in former trials. This may perhaps be partly due to the circumstance of the wind being against, instead of with the sound. The action of the gun is to drive a mass of vibrating air forward in a

definite direction, while the shock of the guncotton is exceedingly local, as has been shown by Professor Abel in many experiments. The gun may therefore be better able than guncotton to make itself heard against the wind. The advantage gained by the bronze howitzer over the cast iron one is probably due to the diameters of the bores; the cast iron 24-pounder is rather too large for 3 lbs., the bronze 12-pounder is rather too small, and excess in size may be more injurious than defect.[1] Both howitzers again beat the long gun, and confirmation is obtained of the previously formed deduction that shape is of more importance than material.

The equality of the effect of the two charges of guncotton is remarkable, and will require clearing up.

It has been proposed to use as sound-producers for the Arctic Expedition small bronze mortars fired with a tightly fitting wooden plug jammed into the muzzle in order to increase the sound, and a certain number of plugs have been sent to the vessels for the purpose. We have hitherto proceeded on the principle that suddenness of shock was a great element of success in sound-producing by explosives, and since the interposition of an elastic column of air in the mortar between the powder and the plug must materially deadens this shock, it was clear that if the plugs proved successful, our principle must be wrong, and hence it was thought desirable to make a trial of the plan. The little parabolic gun on the table was also fired for comparison. Seventeen series were estimated by eight observers, and gave the following results:—

A. Cast iron parabolic gun. Charge, 4 oz. Papier Maché wad	1·00
B. Bronze 12-Pounder Mortar. Charge, 5 oz. (Service charge), wood plug	2·69
C. Bronze 12-Pounder Mortar. Charge, 5 oz. (Service charge), junk wad	2·31

Thus every observer placed the parabolic gun first; and not only was this the case, but it was observed during the experiment that the difference between the loud report and the two low ones was greater than had been the case at any of the previous experiments. The mortar fired with the wooden plug was rather less effective than the mortar fired in the usual way with the junk wad.

Since the parabolic gun combined all the points considered advantageous, such as the best material, length, calibre, shape of mouth, and wad, while the bronze mortar departed from these conditions in all respects, it was satisfactory to find that theory in this case was amply borne out by practice.

Thus far the experiments in this great question have been carried up to the present moment, and I have to thank you most heartily for the kind attention you have given to what has, I fear, been a very dry summary of bare fact. Much remains to be done, the preliminary trials on a small scale have but shown us in what direction to proceed, larger ones will no doubt be instituted; the best combination of effi-

[1] I have since ascertained that the wads used with the 24-pounder were slightly loose.

ciency and economy must be found; whether it will result in the triumph of guncotton or powder none can tell. It has proved a most pleasing task to aid the Great Corporation of the Trinity House in their endeavours to save human life, and perhaps our small share in this effort may be held to atone in some measure for our persistent endeavours to destroy it.

I feel sure you will all join me in wishing success to the Elder Brethren, though I fear it will be long before they persuade us to turn our swords into ploughshares and our guns into fog-signals.

NOTE.—For the experiments which illustrated and enlivened the lecture, the audience and the author owe their best thanks to Dr. Tyndall who lent the apparatus, and to his assistant, Mr. Cottrell, who worked it. Thanks are also due to Professor Barratt, of Dublin, for several valuable suggestions.

FOG-SIGNALS FOR VESSELS UNDER WAY.

By Staff Commander JOHN CUMINS RICHARDS, R.N., Hydrographic Department, Admiralty.[1]

FOG signalling as affecting the sailor, may be divided into two branches, namely, signals from an apparatus on shore, which apparatus is usually in connection with a lighthouse; and signals between two approaching vessels. In the paper read by Admiral Collinson on the 7th instant, and in the one this evening by Major Maitland, we have had an account of the experiments made, to determine what are the best instruments for producing a sound which shall most certainly warn the sailor of his approach to certain fixed dangers. In the present paper, I shall endeavour to state as shortly and concisely as I can, a few ideas on some means which may be employed by vessels under way, to lessen the chances of their collision.

During foggy weather, signals are of far more consequence than at any other time; but the difficulty of signalling is then increased, as sound is the only resource available. It is true, the flash of a gun is, to a certain extent, perceptible through a fog, but guns, however useful they may be as shore signals, cannot on board ship be relied on for the flash.

The present regulations provide that during fogs, steam-vessels shall go at their slowest speed, and shall sound a whistle not less than once every five minutes: sailing vessels shall sound a horn. These directions are admirable for their brevity, but it has long been felt that a system was required whereby a vessel's intentions might be indicated. This feeling has produced inconvenient and sometimes dangerous diversity of custom. In America, a custom has obtained whereby an approaching vessel gives notice of her intentions in the following manner: one blast of the whistle means, I am altering course to starboard; two, I am altering course to port; three, that a

[1] Read at the Evening Meeting, on Monday, May 17th.

vessel approaching or crossing is threatening a collision. This system is perhaps the one most extensively used, as it is compulsory in American waters, but it is only suited for partial use in narrow channels.

Of the various systems of ships fog-signals which have been proposed, some may be mentioned as deserving notice; first, we have had many imitators in sound, of Morse in telegraphy—long sounds and short sounds combined in various ways; but such a system is open to the grave objection of determining by so many operators on the steam-whistle, what is a long, and what is a short sound: such nice distinctions of time are more suitable to the trained hands of a telegraph clerk. However valuable Morse's notation in light may be, as exemplified in Colomb's flashing signals, we may, I think, dismiss its application from the sphere of sound.

An ingenious and yet simple code of fog-signals for vessels under way, has been devised by Mr. H. C. Rothery, Registrar of the High Court of Admiralty. Briefly stated, that code provides that steam-vessels shall use a whistle, sailing vessels a bell: each vessel on becoming aware of the approach of another vessel, shall intimate by sounds of the whistle, or ringings of the bell (up to four in number) the direction in which the sound is heard, and then act accordingly: this method, however, fails in not providing for a distinct utterance of the signals, inasmuch as the duration of the sounds, and of their intervals, is not considered: also the substitution of the bell for the fog-horn in a sailing vessel, materially interferes with the existing regulations.

The fundamental idea of the system of ships fog-signals which I am about to propose, is of two distinct sounds, and for this it will be necessary that all steam vessels shall be fitted with two whistles, one of which shall give a shrill sound, the other a deep or bass sound. The only extra fitment required for the second whistle, would be a branch from the pipe which supplies the present regulation whistle. By some of the combinations of which these two sounds are capable, a code of signals is arranged.

The shrill whistle shall be marked No. 1 and painted green.
The bass whistle „ „ No. 2 and painted red.

All steam-vessels shall make known their presence by a prolonged shrill whistle of not less than ten seconds' duration: but for the purpose of signalling, the sounds from both whistles shall be given in short blasts of three seconds duration, with an interval of three seconds between each blast.

Between each complete signal, a rest of at least ten seconds shall occur.

For greater clearness and to attract the eye, the shrill sounds are denoted in the following table by green strokes, and the bass sounds by red strokes, corresponding with the colours of the whistles. With the exception of the warning signal, which is of not less than ten seconds' duration, each stroke represents one blast of three seconds' duration.

Signal Table for Steam-vessels.

Prolonged shrill			Warning signal.
Signal No.	1, or		I am keeping on my starboard side of the channel.
,,	2 ,,		I am keeping on my port side of the channel.
,,	11 ,,		I am altering course to starboard.
,,	22 ,,		I am altering course to port.
,,	12 ,,		I am steering North.
,,	112 ,,		,, ,, N.E.
,,	121 ,,		,, ,, East.
,,	122 ,,		,, ,, S.E.
,,	21 ,,		,, ,, South.
,,	211 ,,		,, ,, S.W.
,,	212 ,,		,, ,, West.
,,	221 ,,		,, ,, N.W.
,,	1212 ,,		My engines are stopped.
,,	2121 ,,		I am going astern.

The bass whistle is almost universally used in America, and produces a very penetrating sound: the shrill whistle is the one most commonly used in this country.

Sailing-vessels.—All sailing-vessels shall use two fog horns, one of which shall sound a high pitched or tenor note, and the other a deep or bass note. The tenor horn shall be marked No. 1, and painted green; the bass horn No. 2, and painted red.

Signal Table for Sailing-vessels.

Signal No.	1 (warning)		I am on the starboard tack.
,,	2 (warning)		I am on the port tack.
,,	111		I am close hauled on starboard tack.
,,	222		I am close hauled on port tack.
,,	11		I am altering course to starboard.
,,	22		I am altering course to port.
,,	12		I am steering North.
,,	112		,, ,, N.E.
,,	121		,, ,, East.
,,	122		,, ,, S.E.
,,	21		,, ,, South.
,,	211		,, ,, S.W.
,,	212		,, ,, West.
,,	221		,, ,, N.W.
,,	1212		I am hove to.
,,	2121		I am tacking.

Sailing-vessels shall make known their presence by a prolonged blast on the tenor horn if on the starboard tack, on the bass horn if on the port tack. But for the purposes of signalling, the sounds from both horns shall be given in short blasts of three seconds' duration, with an interval of three seconds between each blast.

Between each complete signal a rest of at least ten seconds shall occur.

It will be observed in these Tables that the distinctions of the whistles and horns correspond with the colours of the side-lights; thus the horn which is blown for the starboard tack is coloured green, and that for the port tack is coloured red.

A vessel having heard the warning signal of an approaching vessel, shall signalize her movements or course, which signal shall be answered by the other vessel making known her own course. Guided also by the direction whence the sound proceeds, each vessel will have some important knowledge by which she will know how to act. For example, a steam-vessel, A, steering north, hears the whistle of a vessel, B, on the starboard bow. B is steering N.W., and makes the signal 221. A then knows that B on her starboard side is crossing her track, and threatening collision. By the rule of the road, A will keep out of B's way; this she can best do by stopping or by going astern, A having wisely made the signal 1,212 (my engines are stopped), B keeps on her way. Although the latter, during clear weather, would by the rule of the road be entitled to keep her course unaltered, yet, during fogs, both should stop, if necessary, in order to avoid collision, for it may happen that one may misunderstand, or may not hear the other's signals.

Again, A and B each hear a whistle ahead, both vessels will alter course to starboard and make the signal 11. In buoyed channels, this is perhaps the most common case to deal with during fogs, as it is probable that all steam-vessels will be found keeping on that side of the channel which is best marked, and carefully picking their way from buoy to buoy.

As regards the signals for sailing-vessels, I apprehend the use of two horns offers many advantages, as indicating at once which tack an approaching vessel is on, and with a little practice the other signals might be readily and precisely made, thus removing one of the chief difficulties which has to be contended with. Those who saw and heard the powerful fog-horns which were exhibited by Admiral Collinson in illustration of his lecture, will not have much doubt as to the efficiency of such horns.

Narrow Channels.—Turning to the Steam-vessels Table, it is evident that the first four signals will at all times be useful to vessels under way in narrow channels, and will greatly assist in carrying out, as in the River Mersey, some recent regulations, which oblige each vessel to keep on her own starboard side of the channel. Thus, for instance, a steam-vessel intending to cross to her port side of the channel, would, if another steam-vessel were approaching, sound two blasts of the bass or red whistle, signal No. 22; and the other vessel, if willing to yield her side of the channel, would reply by making the same signal;

but if she were unwilling, would answer by one blast of the shrill or green whistle, which means, I am keeping, or wish to keep, on my starboard side of the channel.

Fleet Evolutions.—The advantages to be derived in fleet evolutions, from the flexibility of the system now proposed, will be apparent. A squadron might, with perfect ease, signalize not only the course steered, but spell out words by means of the whistles or horns. With sounds taken two together, four signals can be made, three together, eight, four together, sixteen, twenty-eight in all. The single sounds may be used to determine whether the signals shall be numeral or alphabetical, that is supposing an alphabetical table to be arranged; and in such practice, where the attention is riveted, the sounds, as also the intervals between the sounds, may be made shorter. With sounds taken five together, thirty-two additional signals can be made; but by using the alphabetical notation, it is not likely that more than twenty-eight will be required.

I will now notice a few objections that will probably be made to the system proposed. The objection most commonly raised is, that we have not in our steam-vessels whistles sufficiently powerful to answer for purposes of fog-signalling. It must be admitted that, as compared with those of American steamers, our whistles are very poor in sound; this is probably owing to the fact that we have less use for fog-signals in this country than they have in America. But the more immediate cause, in many instances, is the want of sufficient steam pressure to blow the whistles. I say in many cases, because the almost universal adoption of high-pressure boilers in the mercantile marine, and the gradual adoption of the same in our vessels of war, has much reduced the number of vessels having low-pressure boilers. The engines of most of our ocean steamers are worked with a pressure of 60 lbs. In the Royal Navy, the engines of the "Malabar" and "Jumna" (Indian troop-ships), and of many other vessels, are worked with a similar pressure.

According to the observations of Sir Frederick Arrow, the 10-inch steam fog-whistle of the Manicouagan light-vessel, St. Lawrence river blown by 65 lbs. pressure, was heard at a distance of fully six miles; the fog-whistles of the United States are blown usually by 55 lbs. pressure of steam.

In the face of these facts, it may reasonably be assumed that we could have in most instances at our command on board ship, whistles of sufficient power for signalling purposes. Whistles, 9 inches in diameter, are already in use on board some of our vessels of war, but they are blown by a pressure of only 20 or 30 lbs.—a force insufficient for the purpose of producing a loud sound.

But by far the most powerful objection which will be raised, is the fact that, in the case of two vessels meeting and blowing fog-signals, it is difficult to tell by the unaided sense of hearing whence the sounds proceed. This objection is supported by the experience of many competent navigators, the difficulty being assumed as inherent to the nature of sound.

"Sound," remarks Professor Tyndall, "is in all respects reflected

" and refracted like light," or, in other words, sound is thrown back and bent out of its course by intervening objects, thus producing echoes and deflections. In this statement we have, I venture to think, a solution of the difficulty commonly felt; for the usual position of the whistle on board a steam-vessel is within six or twelve inches of the fore side of the funnel; this position, although a safe one, is no doubt well adapted for producing echoes. Let the whistle be placed in such a position as shall, after experiment, be found best suited for sound, and then we shall have a trustworthy fog-signal. " The ear, when " undisturbed by echoes, becomes, with a little practice," according to the observations of Professor Tyndall, " capable of fixing with great " precision, the direction of a sound."

Having stated the most important objections that can be urged against ship's fog-signals, I will conclude with the hope that such signals may be considered worthy of experiment on a fitting scale.

The CHAIRMAN: The meeting will regret very much that Professor Tyndall himself has not been able to be present. It would have added greatly to the interest of a meeting already interesting. And now if any gentleman has any remarks to make, we shall be very glad to hear them.

Captain Sir FREDERICK ARROW, Deputy-Master, Trinity-House: You have been good enough, Sir, to invite some remarks upon the question before us to-night, and I hardly think I should do right in remaining silent after the interesting papers which have been laid before you; and also after the great skill, care, and attention brought to bear upon this question of fog-signalling by the Ordnance Department of the Royal Artillery. I am hardly perhaps capable of following so closely as I should like to do, Major Maitland's admirable sketch of the operations they have performed, but I think it will carry home the conviction, as Major Maitland himself said, that we are on the high road to success. I lay very great stress on the fact that after these experiments with small charges, and the comparisons of the experimental guns adapted to the small charges, it seems probable that they will work out satisfactorily on the larger scale with the charge we use ourselves, viz., 3 lbs. of powder. I think there is no doubt at all that the short howitzer pattern, with revolving chamber made upon the principle Major Maitland describes, will not only be a very great relief to the men who have charge of it, but will give an amount of safety which has never yet been secured without a lengthened interval of time between the discharges. The limit of the interval of time should be certainly under a quarter of an hour, and in that direction alone it is a great advantage to know that by means of this rotating chamber we shall be able to repeat the sounds much oftener. Turning back to the experiments to which I have more directly had my own attention directed, viz., those carried out by the Trinity Board under Dr. Tyndall's guidance, I believe they have produced results of the greatest importance, and I must say that the thanks of the world are especially due to Dr. Tyndall, not only for those results, but for the admirable way in which they have been demonstrated so as to carry conviction along with them. I venture to say that although some of the results are in entire opposition to all previous philosophic theories as to sound, it is characteristic and shows the courage of the man that he did not hesitate after sufficient proof boldly to enunciate new principles which have since been attacked. One of the chief advantages of Dr. Tyndall's assistance, in addition to his scientific knowledge, was the extraordinary care and patience with which he pursued his investigations. Not once was anything left to chance. Every experiment was followed out, worked through, repeated over and over again until conviction was certain to his mind; and I feel sure in dealing with so difficult a subject, such a method was invaluable. With regard to the general question of fog-signals, many theories have been expressed during the last few days after the unfortunate shipwrecks which have taken place, but I may remind you that it is not always that you can put theory into practice. Moreover,

in the remarks that have been made upon the loss of the "Schiller," it has been said over and over again that if there had only been telegraphic communication from the lighthouse to the shore, many lives might have been saved. To my mind, such a view is an absurdity. It is not anybody's business to lay a telegraphic wire, except as a speculation, which can be made to pay; but even supposing it could be made to pay, there is no room in such a confined place as a rock lighthouse for the apparatus, and then the men have their other duties to perform, and if in addition to that they are to be telegraphic signalmen, to have charge of guns and guncotton, or any such explosive fog machinery, it would simply wear them out and interfere with their keeping their lights in proper order. Every rock light to a certain extent must be circumscribed in its area, its very strength depends upon it; the chief feature in such a structure is smallness, combined with solidity and great weight. In such a place you have isolated three men, three men who have much anxiety and responsibility, who have only a short period of rest at a time, and if additional duties were put upon them it is quite likely that they would break down. I heard the fog lasted, in the case of the "Schiller," something like three days off and on. Fancy the anxiety of these men if they are to be giving signals every five minutes during that time; and if they had had powder and guncotton it would have been extremely dangerous. I do not think the lighthouse authorities would be justified in allowing them to be placed in the lighthouse, because the loss of the lighthouse itself might follow from the fact of having these dangerous explosives fired, and stored in such quantities as would be necessary. I am quite certain the fog-signals will be an unmitigated boon and blessing to humanity. Nothing in all my experience as a seaman has ever given me so much care and anxiety as the fact of being in a fog. We know what bad weather is, what heavy seas are, those dangers we can see and face; but in a fog, dangers may be about us but they cannot be seen, and the anxiety increases the longer the fog lasts. In reference to the matter, Commander Richards has turned his attention to what is of very great value, namely, signalling for ships under way, but I venture to say it will be a very great mistake whenever we get into what I may call a simply theoretical line. There are many classes of seamen. The officers of Her Majesty's Navy, the officers of the great steam-ship companies, and the officers of many sailing ships are men who are intelligent, trained observers, but they do not constitute the great bulk of the people who follow their vocation on the water. The idea that has always been acted upon in the Trinity House is that safety is wanted, not for the intelligent men, but for the unintelligent; and if we sanction a code of signals which is beyond the comprehension of the most stupid of our seamen, we are going out of our path, and are inviting disaster. Our efforts should be as far as possible, while we accept all the improvements of modern days, to put them within the comprehension of everyone; and, therefore, when I am told we should depend upon these different pitches of sound and depend upon a code, then I would ask, are those proposed distinctions, and is that code, things which everybody can understand? I am quite sure every intelligent man would understand them and appreciate the efforts of Commander Richards, but at the same time a great many will think he has gone too far. I am inclined to that view myself, and I think in his proposals he goes beyond the point of absolute safety. I am not inclined, as far as my humble judgment goes, to see us step out of that straight and simple line which we know will produce good results; and, therefore, when I see it proposed to apply all these improvements of modern days, all the refinements of fog-signals and sounds, in such a manner as will tend, in my opinion, to encourage carelessness in navigation, I feel that we are better without them. Look at the unfortunate "Schiller;" if the captain had followed the good old practice of seamen, and had used his lead and put his head right away from the coast he would not have lost his ship. *De mortuis nil nisi bonum;* but, at the same time, I cannot help thinking if that ship had been sailed upon the true old principle of making sure, the disaster never need have happened. But, unfortunately, there is a struggle to be always first (a very right thing to a certain extent), to which I should be the last man to object, but then that, unhappily, leads very often to want of care and consequently loss of life. Now if this ship had not been poking into Scilly, which every seaman ought to avoid in almost any weather, especially in a fog, she would have been safe. He simply wanted to telegraph to his agent at Plymouth to ge

him coals, and to telegraph on to the continent, and for that he ran the most frightful risk. There is no doubt, because it is as well known to every one as it is to a sailor, that you may take a ship into the English Channel by means of the lead just as if you were reading a book. A more fatal calamity brought about by want of careful attention I think I never heard of. In this case I do not simply say to people—practice what I preach, because I myself have practised it, and I can safely say I have come in a sailing ship all the way up the channel more than once, without ever seeing an atom of land or knowing where I was, except by means of the lead, the whole way up to the Downs. If that could be done then, and I am speaking of more than twenty-five years ago (since which time I have not commanded a ship), what ought to be done with modern appliances? No, they forget to make the best use of modern appliances, and they run these frightful risks for the sake of some little gain. It cannot be impressed too strongly upon the community at large that human life is worth more than money, and in this case no money can possibly repay the loss. With regard to fog-signals generally, I would only say as a matter of information to the audience, although they have been very well informed by what Admiral Collinson put before them the other day, that the Trinity Board have made a great stride in fog-signals; not that I mean any great advance from one point to another, but from this knowledge, that fog-signals can now be made useful at certain distances. The fallacy, and the fatal fallacy which the Americans and the United States Government, also the Canadian Government, have promulgated, was to say that fog-signals could be heard at the longest ranges possible, instead of saying that they could be heard at the shortest ranges. When I was in Canada I pointed it out to the authorities, but I have not seen any practical result. At the same time I hope to see them before long, for it is a mere delusion to tell a man he can hear a signal fifteen miles off, after these admirable experiments, and the report of Professor Tyndall, in which he demonstrates, as plainly as words can say, that except under the most favourable circumstances no man ought to trust to a fog-signal more than two or two and a-half miles to make perfectly safe. Acting upon that, and with the knowledge that the denser the fog is, apparently, the better the results you get, then I say a fog-signal is of real value when it is known that under all circumstances it may be heard at a minimum range of two to two and a-half miles; and we have gone further than that, because we have made a rule that if a danger extends more than a mile, or a mile and a-half beyond the spot where a fog-signal can be placed, we will not venture to put it there, because ships must have room to get about and manœuvre. An instance of that occurred the other day at Heligoland. The Trinity Board were very much pressed to put a fog-signal at Heligoland, and very useful it would have been if we could have insured its being always heard at a distance of three miles. But we could not do that, and sooner than give a delusive warning, we made up our minds not to give any at all. There is a great inducement to us to proceed in the path in which we are now advancing, and I hope the day may come when we may get sound very much more certainly at greater distances, then we may do that which we cannot do now. As an instance of the caution which I consider ought to guide all administrative bodies that have so much at stake, I would say that our motto is to keep within bounds, and never to promise a thing that we cannot perform.

Captain Close, Trinity House: There is one point I should like to see made a little more clear. The papers have stated that it would be a great advantage to have telegraphic communication between the lighthouses and the shore, and that has been taken up very much by firms in the city. The great question is, what use could have been made of those wires if they had been there? They were aware at St. Mary's, Scilly, by the fishing boats and boats from the wreck, that a vessel had been wrecked, and it was only some hours afterwards that the fog cleared off sufficiently for the people of the lighthouse to see that the ship was lost, and no help could have come by means of the wires. I mention this, because the public press of London have very largely advocated what I believe would be utterly useless, and I think, generally speaking, nautical men are very much of my opinion. There might be cases in which a report could be sent when a ship was wrecked at the lighthouse itself, but very little use could be derived from it.

Admiral Sir Henry Codrington, K.C.B.: In all that Sir Frederick Arrow has

said, I think I fully join. With respect, first of all, to the manner of signals, I quite agree it would be a dangerous thing to introduce the signals brought forward by Commander Richards amongst a seafaring population generally; but I should be glad to see something like it in the Royal Navy. I think it would be of use there; but I should be very sorry to see it introduced generally among the whole of the maritime population. Turning to these various means of producing sound (fog-horns, guns, &c.), it seems to me we have not got the best shape even now. I do not think even the best of them is the right shape for our purpose. In our lighthouses, which are so admirably fitted and served, we have the most excellent plan of utilizing all the rays of light which would otherwise be dispersed, either above or below; that is to say, we use the glass prisms, and every ray of light is utilized, so that in whatever direction a vessel comes she is sure to see the fullest power of that light. But what is the case with all of these sirens, fog-horns, and guns? Unless a vessel approaches in the full front of the siren or trumpet, she does not get the warning she ought to get. It seems to me we should treat sound somewhat in the same way as we treat light, that the sound should be reflected horizontally and dispersed somewhat on the same principle, not the all-round principle as in these steam whistles, but that we should disperse it equally from one side to the other of the requisite horizontal angle, from starboard to port as it were, simultaneously; and, moreover, lose none of it upwards and none of it below. But as it is, every one of those appliances that I have seen, whether steam whistles or those that I now see before us, can only give a very limited area of sound, either in extent or in horizontal plane. I should be glad if invention would give us something better by widening the mouth of these fog sirens or guns, horizontally, so as to give as full a sound as possible in each direction contained within the angle required for warning. We should want it on that side, we should want it on this side, and it should be what I might call an equalizing sound, so that none should be lost above and none below, nor to the right or left beyond the required angle. I do not see that we have got that in any of those, and that is a principle I should very much like to see.

Captain Harry BRENT, R.N.: I am afraid I quite disagree with Staff-Commander Richards as to the shrill and the deep sounds. The deep sound is heard much further than the shrill, and when you come to a question of notes, people will differ almost as much as they will about colour. In lights you will find many people will not agree as to colour, and you will find people will not agree about notes. Experience has taught us that the shrill sound is not heard so far as the deep sound; therefore there may be times when you only hear the deep and not the shrill. The lecturer said it would not do to rely upon long or short sounds, because you could not tell the difference. The experience of our fleet is, that we can make that distinction, and the ships can hold communication and tell one another their whereabouts in a fog quite easily, the only limit to the signalling being the distance. I should think it is quite possible, as a siren is better than a steam whistle, that we might have sirens for the service of the fleet. Captain May, of the "Northumberland," did something of the same sort; he filled the steam launch's engine with air, and fitted to it a fog horn, which answered very well indeed. I think it is quite within the bounds of possibility that inventors might devise for our ships a small siren with a small air pump, so that you could fill a chamber and make your long and short flashes. The system of the long and short flashes being used in so many ways is much better than loud or shrill or deep sounds; you use it in everything, and people are accustomed to it—certainly everybody in the service. I am in hopes that the fleet may be furnished with some gun with which to signal. Officers are placed in great difficulty to know the best gun to use in the fleets. The Channel flag ship has had sometimes to clear away all one side of her battery in case of making signals, and if these small guns give such good results, one hopes we may have something of the same kind supplied to our ships, certainly to our large ships, on purpose for fog-signals forming part of our system.

Sir Henry CODRINGTON: I have had something to do with using guns for fog-signalling, but there was always very great difficulty, and there always will be, in trusting to guns for fog-signals, unless there is a small gun which may be placed in a definite position in each ship. Sometimes a gun is fired on the starboard side, and it will give a very different sound from a gun fired on the port side; therefore, if

we are to trust to guns for fog-signals, we should be much rather content with having a small gun for fog purposes placed in a definite part of each ship, so that each gun fired for fog-signals might give the same sort of note, not as different as it sometimes is, according to the locality in the actual ship herself.

Mr. STIRLING LACON: I desire to point out that in crowded thoroughfares such as the river, or the Swin, hundreds of vessels may be at anchor, others tacking, and steamers passing in and out among them. Any person who has been in a fog under such circumstances must be aware how confusing are the sounds of bells, fog-horns, and steam whistles, and how impossible it is to judge precisely the direction these sounds come from. I think, therefore, it would not be practicable to carry out a series of telegraphic sound signals of the nature proposed by Captain Richards.

The CHAIRMAN: I should like to ask if the observations on the several sounds (by small guns of different forms) were taken at the same time, that is, if the observers were all employed at different distances at the same time?

Major MAITLAND: They were taken by one party of observers who varied their distances and they were all together.

The CHAIRMAN: I think more interesting results would have been obtained if parties had been at different distances on the same day.

Major MAITLAND: We should not have got the averages.

The CHAIRMAN: I understand from Sir Frederick Arrow that there is no advantage in the signal being heard further than *two* miles, or that a law must be laid down that all signals are not supposed to extend beyond that.

Sir FREDERICK ARROW: It was that you should not lead people to expect more than you could at all times perform.

The CHAIRMAN: The difficulty of that is evident because you have a signal that may be heard fifteen miles.

Sir FREDERICK ARROW: I mean, if a man expects to hear a signal five or six miles off when, by the state of the atmosphere, he cannot hear it more than two, that is a positive evil.

The CHAIRMAN: He is to assume on all occasions it is not more than two miles?

Sir FREDERICK ARROW: He should not attempt to guide himself except within the minimum range.

The CHAIRMAN: I think with regard to guncotton the question of cheapness should not be taken into consideration in an important matter like this. The question is one of storage room rather than of expense. I will now ask Major Maitland to offer any observations he has to make in reply.

Major MAITLAND: If you take the same price, you can take more powder and make more noise than with the guncotton. It is very well to say you can employ guncotton, which will cost still more, but then you can take more powder at the same cost and make still more noise. At Lundy, during 507 hours of fog in 1873, they fired about every quarter of an hour. When we fire every five minutes, as we hope to do, that will be 6,000 times from one gun. I do not know how many guns they are going to put round the coast, but supposing it to be 100, that would be 600,000 rounds, or, at 2*s.* a round, £60,000. Therefore, price has something to do with it. Sir Frederick Arrow has very kindly made some remarks about the efforts of the Royal Gun Factory. I am sure I may say for Colonel Campbell and myself that it is the greatest pleasure to us to work with the Trinity Board—they treat us so well and accede to our suggestions so readily. Admiral Codrington mentioned that he wished to disperse the sound in a horizontal direction, to go sideways and not above or below. I think that would be a very good plan, but I do not know that we could give you the mouth of a gun that would do it: it is purely a mathematical question. The parabola sends the sound straight forward, but I do not know any curve at this moment which would send it out in the direction Admiral Codrington wishes. I do not think there is such a curve; still there may be, and we will try and work it out. I think that is all I need say with reference to the points raised in the discussion.

Commander RICHARDS, R.N.: Of the several objections made this evening to the propositions that I have started, I will notice the most important one first, and that is about the difficulty of using such a system in crowded navigation. In theory that is a very powerful objection, but in point of fact it is a very small one. On the

coast of America there is an enormous coast traffic, and it is well known that vessels there run full speed regardless of fog. When they have run their estimated distance, they stop, blow the fog-signal, and confidently expect to hear one from the shore, and so they go on amidst a large number of ships. That fog-signals are required is evident from the fact that the Americans have introduced them; signals, perhaps, not quite so complex as those now proposed, but, as I have pointed out, their use is very small. The reason I have proposed two distinct sounds is to give sound-signals a larger scope of usefulness. It is quite possible that in fogs the whole of those signals might not be required. Take, for instance, the steam-vessels signals: the probability is in narrow channels, where navigation is most crowded, only the first four signals would be required, and perhaps the last two. As regards the long and short sounds for signalling purposes, I must differ from Captain Brent. I think there is liable to be great confusion, whereas with my system you have simply to tell the man "Blow two green and one red," &c. I do not mean to say that this system is perfection, but I hope it will have a trial. We have no system of fog-signals in this country for vessels under way; every system that has been brought forward has been put aside owing to the various difficulties which I have stated. I hope I have successfully disposed of those difficulties. Sir Frederick Arrow made a remark that we should have a code that everybody could understand. I may not have been very clear in my explanation, but I think if the list of signals were printed and hung up in the wheel-house, being, as it is, a sort of coloured picture, it would soon be mastered. I quite agree that it would be inadvisable now to introduce such a system generally: the matter requires consideration and experiment. It has been said this evening, during the discussion, that deep sounds can be heard further than the shrill. Authorities are divided on that subject. I know the Americans have that opinion, because all their whistles are of deep tones; but a very general impression prevails amongst many people whose opinions are entitled to weight, that shrill sounds are most penetrating. What we require is a series of experiments carefully carried out to decide these disputed points.

Major MAITLAND: There is one point I omitted to mention. The gun is supposed to be turned round and to fire in any direction you follow, so that you get the longest possible reaching sound in every direction, and dead to windward, too, if preferred.

The CHAIRMAN: It now devolves upon me to offer the thanks of the meeting to the gentlemen who have so ably brought this subject before us.

Evening Meeting.

Monday, May, 31st, 1875.

VICE-ADMIRAL SIR FREDERICK W. E. NICOLSON, BART., C.B., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 18th and 31st May, 1875.

ANNUAL.

Thomson, C. F., Captain 7th Hussars.
Lambert, Walter M., Lieut. R. M. Artillery.
Maltby, J. M., Lieut. 1st W. I. Regiment.
Auchinleck, Wm. L., Captain 53rd Regiment.
Lloyd, Thos. F., Lieut.-Col. 98th Regiment.

A NEW SYSTEM OF NAVAL TACTICS.

By Lieut. GRAHAM BOWER, R.N.

THE subject which I have the honour to introduce this evening is one that during the last few years has received considerable attention from the Naval Officers of all maritime Powers.

Despite, however, all that has been written and said on the subject, no definite conclusion seems to have been arrived at, and our Navy is, at the present moment, without any certain idea as to the system of tactics that it would be called on to pursue in any future naval action. That this is the case I imagine is a good deal due to the fact that we have been too much in the habit of studying tactics without considering the enemy; playing Hamlet, in fact, with the part of Hamlet left out.

The past history of the subject gives us but little information; our victories during the great war were few, if any of them, due to tactical skill, and for the causes that determined the result, we must look outside the field of tactics.

To the modern student of the subject this is no great loss, steam and armour-plating have so altered the conditions of naval warfare that there are few lessons deducible from the ancient battles that would be applicable to modern times.

The only great battle of our day, the battle of Lissa, is equally

meagre of information, having been lost by mismanagement rather than won by skill.

We have, then, as Commander Noel so well puts it, to trust to our imagination for our ideas of future naval battles.

But, nevertheless, our imagination is capable of affording us ample materials for arriving at a right judgment.

The manœuvres of an enemy are necessarily restricted to certain mathematical figures, and we can easily consider the formations it would be most advisable for us to assume to meet them.

We have at present in our signal-book two systems; one, that I will call the "division system," which divides the fleet into divisions, subdivisions, &c., &c., and presumably proposes that the attack should be made either in extended, narrow, or deep and medium formations.

The other, the "group system," I shall assume to be well known to my audience, and to require no description from me.

At the time our signal-book was altered, to admit the former of these two systems, a change, and as I maintain, a change for the worse, was made in the system of evolutions. I allude to the flank movement, to which I shall shortly draw your attention.

These systems that I have spoken of have been built up on totally different principles to the system I advocate; my contention is, of course, that my own is right. It is important, however, to keep in mind the difference in principle. In the two existing systems it would seem that a system of evolutions has been constructed suited to the requirements of a fleet during peace, and from this, certain formations have been selected as advantageous for use on the field of battle. In forming my system, I have begun at the other end; I have asked myself what possible formations can an enemy assume; I have then asked myself, what formations would be most advantageous against them; and lastly, what are the evolutions necessary to their execution?

Now, in introducing a new system of tactics this evening, I feel that it is not sufficient that I should show that mine is good, but also it is necessary that I should show it to be better than those already existing.

This, then, must be my excuse for commencing my lecture with a criticism of the two systems I have spoken of.

I will here state briefly the manner in which I propose to divide my subject this evening.

(1.) To endeavour to show the weakness of the "group-formation" considered tactically.

(2.) To endeavour to show the danger of the so-called "flank "movement."

(3.) The fallacy of the attempt to confine the tactical formations to certain limits, necessitated by the organization of divisions.

Lastly, to introduce a system of evolutions, and of tactics, differing from the foregoing, and based on the definition of tactics, namely, an endeavour to manœuvre on the field of battle, so as to outwit and overcome an enemy.

I do not claim perfection for my system; we live in an age of pro-

gress, and doubtless, in time, a system will be found to defeat mine, but I do claim that it is better than any at present in existence.

If in the remarks I make in my paper I appear to criticise somewhat closely the opinions of those who have preceded me, I beg that you, and they, will understand that I do so in no carping or jealous spirit, but with the object we all have in view, viz., the elicitation of the truth on an all-important subject.

In considering the first portion of the task I have set myself this evening, namely, to prove the weakness of the "group system" as a tactical formation, I intend to take Commander Noel as its latest and most authoritative exponent.

The system has numerous other supporters, but, to consider and answer all of them, would be to waste the time of this meeting. Commander Noel has put the case as strongly and as clearly as the position admits of. He says—

"Groups once having been formed, the ships should not be changed, "the great object of groups being that each ship, by constantly hold- "ing the same place, will get to know its position and the movements "of its companions in the group; by this plan the comparatively few "manœuvres that are required when working in groups will be taught "to eighteen ships, in six groups, as readily as to six ships not grouped."

Again, quoting Commander Pellew, whose remarks are endorsed by Commander Noel:—

"This system of cutting up large fleets into smaller bodies, so much "more easily manœuvred, I consider to be of essential importance, "especially with respect to the facilities it affords for rallying or "detaching, and for keeping ships together at night."

Here, then, are special advantages claimed for groups. I will now put the other side, as it appears to me.

My objections then to this claim are as follows:—

(1.) The arbitrary resolution of a fleet into large tactical units restricts the mobility of the fleet, and limits the number of formations it is capable of assuming.

(2.) That it necessitates a permanent delegation of authority. That this is liable to end in desultory and irregular action on the part of subordinate commanders. That this irregular action can never produce the same result as perfectly harmonious and concerted action.

(3.) That this harmonious and concerted action can only be secured by the unification of command and responsibility.

(4.) That where a necessity arises for a delegation of authority, that delegation should cease with the period of its necessity, and should be granted to the person or ship so situated as to be in the most advantageous position for exercising it.

(5.) It is assumed that manœuvres would, on this system, be as easily taught to eighteen ships as to six.

I can see no greater difficulty in teaching manœuvres to eighteen ships than to six whatever system we adopt. Group-leaders have no special monopoly of intellect that I am aware of.

(6.) The merit claimed of accustoming ships to work together in a group, I maintain to be in reality a defect.

DIAGRAM OF NAVAL TACTICS

Fig. I.

Fig. II

Fig. III

Fig. IV

Fig. V.

Fig. VI.

Fig. VII

Fig. VIII.

Fig. IX.

Fig. X.

J. Jobbins

It will not have escaped the notice of my hearers that soldiers are discussing the propriety of accustoming men of different regiments to work together in a battalion or company. Now in forming permanent groups we are, if I may use the word, unaccustoming ships to work with other ships of the fleet.

(7.) To borrow another illustration from the Army, we are, in forming groups, creating a front and rear rank.

I need hardly point out that the establishment of a permanent front and rear rank would be a sacrifice of mobility; yet in groups we are creating precisely the same things.

Commander Noel quotes Captain Colomb's remarks on angular formation.

He, Captain Colomb, says:—

"In my former paper I endeavoured to point out that, however "valuable in theory this angular formation might be, it was so un-"wieldy and difficult to maintain, that practically it was valueless."

One would hardly expect an advocate of group-formation, to quote such an emphatic condemnation of angular formation, with approval, yet such is the case.

I can only say that my own experience convinces me of the truth of Captain Colomb's remarks, and of its application to all angular formations, groups included.

(8.) I again quote Commander Noel on groups. He says:—

"Having headed towards the enemy, there are, I think, when work-"ing in groups, only two formations in which to place the fleet for "attack.

"Groups in columns of two divisions in line-ahead, and groups in "line-abreast."

Now if this be the case, groups can certainly not claim to be a tactical formation at all. It would certainly require an unusual amount of imbecility on the part of an enemy to place him in a condition unready to meet an opponent whose stock of tactics, prepared to outwit and overcome him, is limited to two formations!

(9.) One last merit claimed for groups requires consideration, namely, that they afford means of rallying. Now let us examine this; let us suppose a fleet to have passed through an opponent's line, and that one of the groups has lost two ships, another one disabled, not a very improbable case surely; yet, if the Admiral intends to turn and renew the charge, he must reorganize his fleet anew before doing so.

(10.) The last, and perhaps, most fatal objection to groups on the ground of principle, is, that they necessitate the use of compasses in action. Now from the time the first shot is fired in a naval battle compasses are useless, and a system requiring their use must break down. This applies to all angular formations.

I now come to special objections against groups. Fig. I represents the original group of four ships attacked by a "pair" in lines-abreast.

The "pair" advance, empty their inside broadsides in exchange for the outside ones of the group-leader. Exchange broadsides with the wing-ships of the group, and then turning, together ram the rear-ship.

For this vessel there is absolutely no escape, not even in flight.

This particular form of group is now obsolete, and I only intend to use it here to illustrate a principle.

The ships marked (A) form the group, those marked (B) the pair.

Fig. II represents an attack by a pair, on a group formed on Commander Noel's system.

This group is formed in the following manner:—Ship (2) forms five points abaft the starboard beam of ship (1), and two cables from her. Ship (3) forms six and a-half points abaft the port beam of ship (1), and four cables from her, being then four points abaft the port beam of, and three cables from, ship (2).

The pair advance in line abreast, steering in such a manner that the port ship of the pair may pass close to and on the port side of the group-leader; the starboard ship of the "pair" steers in such a manner as to keep on the port bow of the rear-ship, and at the same distance from her as her consort in the pair.

Now on closing, the leader and port ship of the group exchange broadsides, the pair pass on, receiving another broadside from No. (2) of the group; when within convenient distance they turn together and ram the rear-ship of the group.

Now, in these two attacks on groups by an inferior force, the rear ship has in each case been selected for ramming; the reason being that her comrades are so placed as to be incapable of rendering her any assistance; indeed, I can see no possible means of escape for the third ship of the group; it would be too late for flight, once the pair have passed the leader; to turn towards one or other of her enemies would be to expose herself the more to the other.

I will now leave the subject of groups for a moment, and consider the defects and dangers of the flank movement.

This evolution was introduced when the new signal books were published in 1867, and is mathematically the shortest method of forming line abreast from line ahead; it has been adapted to most of the changes of formation in our signal-book, as, besides being the shortest method, it has the further advantage of not requiring any alteration of speed for its execution; as a peace-evolution it is unrivalled for simplicity and rapidity, but as the British Navy exists for other purposes besides peaceful reviews and exercises, so our signal-book should be formed to meet the conditions of war.

In Fig. III, I show a fleet endeavouring to perform the flank movement in the presence of an enemy. The fleet marked (A) is shown trying to form line abreast in presence of a hostile fleet marked (B), which is already in line abreast; the leading ships of (A) have turned, and have their broadsides exposed to the rams of the fleet marked (B); these leading ships have the choice of two alternatives, either to continue the movement and be rammed and sunk, or to turn towards their adversaries, thereby disorganizing the fleet of which they form part.

There are in our signal-books several blank spaces, left so, I presume, for the purpose of allowing a Commander-in-Chief to fill them up according to the requirements of the fleet. If such be the

intention, I can only say, nothing can be more mischievous. An Admiral's alterations and additions do not extend beyond his own immediate command; and were a squadron reinforced on the eve of an engagement, by ships from another station, there is no end to the disaster and confusion that might accrue from the fact, that different portions of the same fleet would be using different signal-books.

Another point to which I wish to draw attention is, that there is an idea afloat in the service, which I find expressed by Commander Noel and other writers, that before an engagement, an Admiral should hold a conference to determine his mode of attack.

Now, I ask, why put it off till then? if a conference be necessary, why not hold it now? an Admiral at sea is not likely to have any more information available than we possess on shore; surely we are as well informed as to the strength, and composition, of foreign navies now, as we would be at sea. A fleet should at all times be prepared to meet an enemy; there may not be time to hold a conference, and an Admiral on the eve of an engagement will have enough to think of, without the addition of a council of war, which, if we may believe a proverb, "never fights."

I now come to my own system of tactics; it requires a special system of evolutions. As it would be beyond the scope of this paper to go into all the evolutions in detail, I will content myself with indicating the leading points and principles on which the evolutions are based.

(1.) I accept it as a rule that, in every change of formation, the bows of all ships should, as much as possible, be kept pointed towards the enemy.

(2.) That during the period of the interlocking of fleets, an Admiral is unable to exercise any authority over the ships under his command, and that a delegation of authority is necessary.

I provide for this by arranging that, after the fleet has assumed its formation for attack, and when it has arrived within a distance of 1,500 yards of an enemy, it is to be considered divided into "pairs."

(3.) A pair consists of two ships, whose duty it is to act in concert, and direct their combined efforts to ramming the single ship of the enemy's formation, against which they may be directed.

(4.) The senior of two ships forming a pair need not necessarily direct the pair; the direction being assumed by the ship nearest the Admiral, as he is best situated to observe the Admiral's motions, and decide correctly.

Now here I am aware that I am introducing a principle contrary to all our ideas of discipline and subordination; but I am sure that, if I succeed in proving that it gives a tangible advantage, there will be few objectors to it. We have already in the service a rule, that an Officer from the flag-ship takes command, whatever his seniority; this is merely an extension of the rule, with more reasons to allege in its support.

We all of us, I imagine, understand, that during the period of the interlocking of two hostile fleets, the area of vision will be very

limited, and that if the senior ship of a pair be the farthest from the Admiral's, he is from the circumstances of his position, unable to assume the direction.

(5.) The organization of pairs ceases directly the fleets have "drawn the battle clear," and the ship becomes as she was at first, the tactical unit.

(6.) Every ship on joining a squadron should receive a fleet-number; this number would represent her place in line ahead, it should be kept continually flying at the main, and be liable to change on the fleet being ordered to "tell off."

(7.) A squadron has no permanent right or left, front or rear; the Admiral need not necessarily lead the squadron; the same rule applies to the placing of ships.

These are the principles on which the evolutions are formed; I now come to their application.

To meet the first of the seven requirements I have spoken of as essential to a system of evolutions, I would recommend the old-fashioned method in effecting any change from line-ahead to two columns, in forming line abreast, or increasing the number of columns, in fact, for every purpose for which the flank movement is now used. I imagine that most of my audience are already acquainted with this method, but for the benefit of any of those who have not practised it, I will give a short description, together with the modifications I would propose, in order to give increased mobility.

A squadron on assembling, would form line-ahead in the order of their fleet-numbers.

From line-ahead, to form two columns, the odd numbered ships turn to starboard, the even to port; on arriving in position, in column, the leader of the starboard column would hoist letter A, in addition to his fleet-number already flying, and the leader of the port column would hoist B, in addition to his number, the signal would then be made "tell off," and the ships would hoist numbers corresponding to their places in the column in which they might find themselves.

To double the number of columns would be to perform the same manœuvre, "telling off" afresh after each manœuvre is completed, and each column being lettered.

On arriving in line-abreast, which the ships must do if this signal be repeated often enough, the ships would "tell off" from the right, as in Fig. IV, the old numbers are placed below the ships, and the new ones above.

This, of course, would not be the ordinary mode of forming line abreast, which would be as follows:—

The ships, odd and even, steam to their places on right and left of leaders, when the signal is again made "tell off."

In all cases in line-ahead, ships would "tell off" from leaders.

In line-abreast from the right.

In quarter or bow-lines from the ship most advanced.

In angular formations there would be two Nos., (1); in the case where the vertex of the formation is in front, the ship at the angle, and the one on her starboard-quarter would each be No. (1).

In angular formations where the vertex is refused, the ships on the extreme right and left would each hoist No. (1).

The formation of pairs, when the fleet are in columns in line-ahead, would not necessitate any change of position on the part of any of the ships.

Ships flying similar numbers form pairs.

In line-abreast also, no change of position would take place, the pairs counting from the right.

In bow, and quarter lines, and in angular formations, a slight change is necessary, the ships flying the highest number moving up to take station.

In these (the angular formations) it would be necessary to make the signal "pairs," earlier than in other formations, in order to afford time for ships to settle in their places before closing the enemy.

Now the system of "telling off" after every evolution may be objected to, as causing a re-organization of the fleet after every manœuvre.

I will, therefore, give the reasons that induce me to recommend it:—

(1.) No re-organization takes place, the signal to "tell off" causes every ship to hoist a number, which number represents her place in line-ahead, and is an indication that she understands her duty in executing the next manœuvre; it would be quite possible to perform every manœuvre without "telling off," the system is, however, a precautionary one to prevent accidents or confusion.

(2.) As there has been no permanent organization, there can be no re-organization, the system throughout is one of orderly disorder, specially designed to meet the varying circumstances of a battle-field.

(3.) By thus constantly varying the position and duties of a ship, you institute a system which no accident on the field of battle can throw out; if one or more ships be disabled, and have to withdraw from the action, there can be no confusion or hitch consequent on their withdrawal.

(4.) It may possibly be asked, in connection with this system of telling off in fleet-numbers, how we would manage at night, and what substitute would be provided for the numeral flag kept constantly flying by day?

The arrangement I would advocate for this is a simple one. It would be obviously impossible to hoist a string of white lights to represent the number, and I would advocate the use of white, red, and green lights at night, the white light to represent the one, or letter I, in the Roman numerals; the red light, the letter V, or five; and the green light the letter X, or ten. By this arrangement we would be able to make numbers up to thirty-nine, with only five lanterns, the upper lantern representing the letter to the left; for instance, to make nine, a white light above a green one would be hoisted.

My time will not permit me to enter more fully into the system of evolutions. I will now come to the main object of my lecture, the new system of tactics.

Tactics.

The system of tactics which I now introduce to you is based on the following principles:—

(1.) That the ram is the principal weapon of naval warfare.

(2.) That of two ships equal in every respect, and equally well handled, and each desirous of ramming his adversary, neither can calculate on success; but if two ships be brought against one, the single ship must be rammed.

These two principles, I imagine, will meet with few dissentients; they may be accepted as axioms, and require no argument from me in their support.

The object I propose to myself, in this system of tactics is, in all cases, to endeavour to bring two ships to bear against one of the enemy.

For this purpose, I would institute an organization of pairs.

This organization of pairs, as I have already explained, should be merely a temporary one, existing for the time between reaching a distance of fifteen hundred yards from the enemy, after formation for attack is completed, and lasting until the fleets have drawn clear. To make it a permanent organization, would be to lessen the mobility of the fleet. For the same reason, also, the vessel on the side nearest the Admiral should direct the pair, irrespective of seniority. The Admiral's formation of attack should be dependent on that of his enemy. As a pair is intended to occupy the same space as a single ship of the enemy, the fleet should be constantly exercised in manœuvring, at high speeds, in close order.

Figure V represents an attack by a fleet, on an enemy in line-ahead, an instance of Captain Colomb's narrow front.

A and B are two opposing fleets; they sight one another in line-ahead. A should immediately form two columns; should B still remain in line ahead, A should continue his advance, steering in such a manner that B may pass between his columns; when within fifteen hundred yards of his enemy, or within such a distance that a change of formation is no longer possible to B, the Admiral should make the signal "pairs." From that moment, the ships in the Admiral's line should assume the direction of the ship abreast of them, in the other line, still however keeping station as accurately as possible. On passing the van of B's fleet, broadsides would be exchanged, the ships passing on, closing the columns as they do so.

On arriving within a convenient distance, the headmost pair turn together, and ram the rear-ship of B's fleet, the other pairs performing the same manœuvre on the ships corresponding to the pairs.

Now, let us examine the position of the rear-ships of B's fleet. Should they attempt to turn towards either adversary, they expose their broadsides the more to their other opponent; unless the vessels of A's fleet have bungled their work, it would be too late for B's ships to attempt flight; the van ships are in a position that renders them unable to rescue their comrades.

In fact, unless this manœuvre be very badly executed, it cannot fail to be successful.

In Fig. VI, I have supposed that the opposing fleet have formed two columns. It will be noticed that in the figure there are but four ships in each fleet; this, therefore, may be taken as an example of Captain Colomb's formation of equal depth and front.

I wish to explain here, that although I have constructed the diagrams for but four ships in each fleet, my remarks apply to any number of ships.

In the present instance, whatever the number of ships contained in each column, on observing an opponent in two columns, it is necessary to form four columns. The columns are formed, if possible, at half the distance apart that the enemy's columns have. As in the preceding manœuvre, the signal is made "Pairs," and the pairs steered so as to allow the opposing ships to pass midway between them. The pairs on arriving within turning distance of the last ships, turn and ram as before.

In Fig. VII, we suppose the opposing fleet to have formed line-abreast at close order, two cables apart. This may be taken as an instance of Captain Colomb's extended front.

The attacking fleet now form at half distance, in line-abreast, and attacks one or other wing of the enemy's line. The duties of pairs are precisely the same as in the former illustrations.

In Fig. VIII, I have supposed the enemy to have closed to half distance, assuming that it would not be safe to close the ships of the attacking fleet any more, though I by no means admit that this would be the case with a properly instructed fleet. Assuming, however, that it would be impossible to close the ships, the combat would now resolve itself into a trial of nerve and skill between the commanders of opposing ships. Each commander would have to steer straight for his opponent; the first to swerve from this course would infallibly be sunk. This is the trial of nerve I allude to.

If, however, both hold their course, it is possible that both may go down, or that they may cannon against each other, tearing away all outer fittings, and pass on.

Should neither be incapacitated from continuing the action, the victory, or rather the advantage, would lie with the fleet that first turned round to renew the contest; for supposing one fleet to turn before the other, the first fleet would have their bows opposed to their opponents' stern, and these opponents would find it impossible to turn, as to do so, they would have to expose their broadsides.

Fig. IX. In the previous figure it was seen that the advantage lay with the fleet first round.

Fig. IX illustrates a means of securing this advantage to an attacking fleet. The fleet is divided into two ranks, each rank closing its ships as much as is compatible with safety, the ranks to be three and a-half cables distant from each other. This distance is assumed to be the diameter of the circle a ship makes in turning; it would vary with different fleets, and the distance assumed here is to be understood to be merely for the purpose of illustration.

The two ranks, keeping directly astern of each other, steer as in the foregoing figure, the ships of the front rank would jostle their

opponents as before, and immediately putting their helms hard over, turn towards the disengaged portion of the enemy's fleet.

The rear ranks would follow precisely the same course as the front rank until clear of the enemy's line.

Let us now consider the position of the enemy. But half this fleet could possibly be effective; this portion would be unable to turn immediately after the encounter with the front rank, as another similar encounter is imminent; the non-effective portion would be unable to turn toward their comrades, and to be of service must turn away from them. The period at which this fact would be realised by their commander is, however, uncertain, and I have given three illustrations, the positions 1, 2, 3, representing different stages, dependent on the time at which this fact is realised.

Position 1 supposes the movement to have been begun at the moment of the collision of the front rank and the right wing, position 2 supposes it to have been begun some time previously, position 3 previous to this again. Now in position 1 they are in comparative safety, but inoffensive; in position 2 they are in danger of ramming from their opponents' front rank; in position 3 they are liable to be attacked by pairs formed of uneven ships. In the figure, of A's fleet, No. 1 of the rear rank, together with No. 2 of the front rank, would be conveniently situated to form "pairs" of attack.

Whatever the position these ships may be in, it is the duty of the front rank to keep on the side most remote from the ships in the rear rank, ready to take advantage of any opportunity that may present itself of shutting the enemy in between superior forces.

I will now consider the objections to this manœuvre, and to my mind they are certainly grave ones.

Firstly, in separating a fleet into two divisions, on opposite sides of a hostile force, you violate the first and most important principle of tactics.

Secondly, during this time of separation, all communication is interrupted between the divided portions of the fleet, and they are mutually ignorant of each other's condition.

It is true that the period of separation is short, lasting only about four minutes, but a fault is not the less inexcusable, that it lasts but for a few minutes.

For these reasons then, I am not prepared to recommend the adoption of this mode of attack, on *all* occasions, but would leave this, and its predecessor as alternative modes of attacks, the selection of either being dependent on the character and ability of the enemy to be encountered.

In Fig. X, I have illustrated an attack, by a fleet of pairs, against a fleet formed in groups, and arranged in columns of groups in two divisions in line-ahead, I here extract from Commander Noel's book, the tactics adopted by a fleet of groups in this formation.

"If the enemy advances with a narrow front, the first division will "attack by passing along the enemy's line, keeping outside it if possible, "and the second division will charge the enemy, turning towards the "enemy, as the leading opponents meet, so as to come in contact astern

" of the first division, just as the last ship of the enemy is clear, and " before they can have recovered from the first attack."

Now, against a fleet formed in pairs, this brilliant charge, with its consequences, could never occur; long before the second division could arrive on the scene, their comrades of the first division, would have been rammed.

Of this charge and its results it may be said, as once was said of another disastrous charge, "*c'est magnifique, mais ce n'est pas la guerre.*"

I have now concluded the illustrations of my system of tactics, my time has enabled me to show a few only of the modes of attack, but I may mention that I have myself drawn out twenty-five different modes of attack, and the system is capable of extension to twice, or even three times that number.

Throughout every attack, the same principle is carried out, namely, to bring two ships against one of the enemy. Against an enemy formed in any number of columns, this is done by forming double the number of columns at half distance.

Wherever possible, the closest order is kept, as it is evident that the fleet in the closest order, brings a superior force against a part of the enemy's line.

The various column formations, of which I have shown illustrations, are instances of the former of the two systems found in our signal-book.

Their great weakness lies in the want of mutual support incidental to the organization, and in the great want of mobility due to the same cause, the latter evil preventing any really tactical manœuvres on the field of battle, and confining the action of the fleet to its original formation for attack.

For these two evils there can be no remedy short of the abolition of the system; patchwork can produce no real result and will only complicate the evils it is intended to mitigate.

Guns and torpedoes have not been mentioned, the time at my disposal confining me exclusively to the question of rams. I have also ignored the existence of reserve squadrons. My reasons for this course have been stated in a former essay, but as the system has some supporters I will reproduce them here to give an opportunity for their discussion.

" *The employment of Reserve Squadrons in Action.*

" There appears to be a very general impression amongst Officers " that it would be advisable in any future battle to keep a small " squadron in reserve, to be used where the occasion presented itself. " The reason for this course, as far as I can learn, is that there is a " belief that however small the number of ships engaged, both sides " will be pretty evenly damaged and severely mauled after an hour or " so fighting, and that when both sides are exhausted, the arrival of " the reserve squadron will decide the fortune of the day; another " reason appears to be, that in case of defeat the reserve squadron " would be useful in covering the retreat of the beaten squadron.

" Now I cannot but think that persons who advocate such a system

"of tactics have grievously misunderstood the manœuvres of our "future battles. Lord Elcho, at a recent lecture at the United "Service Institution, happily stated his position in opposition to some "retrograde military reformers, saying: 'he was all against bows "and arrows.' Now I think the advocates of reserve squadrons are "all in favour of bows and arrows. They appear to imagine that we "are still in the days of Howe and Jervis and to have forgotten the "revolution that has occurred in naval matters since those days.

"At the time of the old war when vessels hammered away at one "another until one or other was exhausted, the employment of reserve "squadrons might, perhaps, have been of some use; it is possible that "when after some hours' hard pounding, the combatants found them-"selves reduced to the position of the Kilkenny cats and drifting "about as mastless hulks, the arrival of a fresh reserve squadron "capable of sailing round and raking the cripples, might have turned "the day; but even then, it was doubtful policy to keep a reserve "squadron out of action, especially in light winds. At Trafalgar the "rear squadron was routed before the van could succour them. Since "those days a change has come over the spirit of our dream; it is no "longer the good old fashioned pounding in which the combatants "stood up to one another like two prizefighters—enduring their "punishment with an obstinate dogged courage—it is now a combat "between skilled swordsmen, in which one thrust deftly delivered "well home will decide the fortune of the day.

"Events succeed one another so rapidly on the field of battle, and "the weapons of modern war—the ram and torpedo—are so speedy "and decisive in their effects, that each field of battle might almost be "considered a theatre of war in itself. A reserve squadron under "such circumstances could not possibly hope to be of any assistance "to their friends.

"Supposing a reserve squadron to observe that their friends were "exposed to rams, could they arrive in time to save and protect them? "If they are to be a reserve at all they must be stationed so far off "from the combatants as to be out of the action, and would probably "have some difficulty in distinguishing the exact place of the conflict "from the amount of smoke that would hang about the combatants. "It would be easy to show, also, that were an Admiral so minded he "could easily prevent his opponent from keeping a squadron in "reserve, and that by the no more abstruse method than merely "detaching a certain number of his ships to engage them. That, "however, is a course that would be adopted by few in employing a "*reserve* squadron; a Commander gives his opponent an opportunity "of doing that which has been the aim of every skilled warrior from "the days of Alexander downward: he gives his opponent an op-"portunity of destroying him in detail, of routing and destroying "first one portion and then the other portion of his fleet, and in thus "exposing himself, he violates every principle of strategy and tactics. "What gave Nelson success at Trafalgar? He destroyed the rear "portion of the French line before the front portion could turn round "and succour them.

"The great principles of war are the same both afloat and on shore; "and the advocates of reserve squadrons violate the first and principle "rule: namely, to endeavour to concentrate a superior force on a "portion of your enemy's force, and so to rout and destroy your "enemy in detail."

To the above remarks I still adhere, and nothing has occurred to induce me to alter or modify them in the least.

The subject of tactics, however, is as yet in its infancy, and indeed there are but few who can be said to have approached the question at all.

We have hitherto considered fleets equally composed, equal in every respect, encountering in still water, but we have to consider how to take advantage of superior numbers and force, and how best to compensate for inferiority of force.

It is also apparent that vessels steaming against wind and sea, will not attain the same speed or handiness as vessels going before the wind, we have to consider how, if we were in the first case we would endeavour to neutralise the disadvantage, or in the latter case how best to avail ourselves of the advantage. Hitherto also we have spoken only of the first charge of fleets, we have not considered how we may best re-form, to take advantage of the results gained in the first onslaught. My time forbids my touching on these branches of the subject. I must be content to indicate them as works of study, and demanding attention.

It must be remembered that seamanship and tactical skill are born of forethought, and if we are to acquit ourselves in the manner our past history and traditions demand, it is only by earnest and careful study that we can aspire to do so.

I do not think more can be said to commend the subject to all Naval Officers.

The CHAIRMAN: After this able paper which has gone into so much detail with regard to the manœuvring of ships, we hope that some gentlemen present will be ready to offer some observations.

Admiral Sir HENRY CODRINGTON, K.C.B.: I should like to make one or two observations. There is a great deal in what the lecturer has said as to attacking in pairs, though I disagree with him entirely as to the making the ship apparently nearest to the Admiral, the Commander; because even in some of the diagrams that he shows us, the distance between the Admiral and what I may call the starboard ship of the two, is but a trifle more than the further one, and in the close order in which they would be for this purpose (which he very judiciously advocates) I think there would be scarcely any difference, considering the quantity of smoke there would be, and the other impediments, wind and waves, and so on, and I do not see any reason for the temporary unshipping of the senior officer from the direction of the two. Moreover, I think the Admiral should retain the command as much as he possibly can at all times over all his pairs, although the signal may have been made according to the proposal for pairing.

Coming now to the diagrams. I think it is fair to assume that the enemy whom we attack, will at least be as judicious as ourselves in keeping to as close order as we do. We must not suppose that an enemy's squadron is to be conveniently in open order, whilst we go in close order at it. It is fair, therefore, to give him credit for just as much, in short, as we have ourselves; and, moreover, it is also fair to suppose that he is equally determined to ram; in short, equally determined

to use all his advantages of wind, weather, seamanship and material, as we ourselves are. Now, in this diagram (Fig. 1) it is said that these two ships marked B are to turn and ram that stern one. But what in the meanwhile is to take place? Those two ships marked A have passed the senior officer, and have each of them received as good a broadside from him as they would deliver to him. They do not pass on quite unscathed. They are enveloped in a cloud of smoke, unless the wind conveniently blows it away from them all; and it is fair to suppose, therefore, that they do not immediately see what the ships astern of the opposing Admiral are doing. Suppose, therefore, that the ships of the opposing Admiral have had equally good communication with their Admiral beforehand, to know what his general views are on the subject of ramming, and that they are equally determined to ram these two as fast as they possibly can, and not allow them to get through to the sternmost. Supposing as this ship gets in the middle of the smoke she suddenly finds this one coming right at her starboard bow before she is aware of it. I think it is fair to suppose that these two are not likely to get on to the third one astern; they would probably be exceedingly well mauled before they did that, and we must conclude that the accidents of warfare in this sort of way, the concussions and all that took place there, would make a very large deduction necessary from the certainties of the success of a system of this sort. We have no right, therefore, to calculate that those two ships will get through so unscathed and pass the three as to maul the rear one. But supposing that they did get through rather lamed, but complete their original intention of trying to ram him. We may suppose he is not likely to submit to it patiently, but at any rate he may say, "I will take my chance against one of them;" and he goes right at that one; and supposing that takes him on the outside bow, he would cannon off from him before the other could get at him, because he going in this way would reach it before the other one would reach him. We must always remember they are moving at a great rate, and that the opponents do not know each other's intentions, and the man of quickest action in the hour of need, is the man who would win the battle in those cases.

The lecturer also spoke about cannoning. There was an instance of cannoning which I happen to know of, from the explanation given to me by one of the parties to the conflict. It was a case of a German and French ship in the West Indies, and I happen to have had the pleasure of the company of the commander of the German ship at Devonport. He gave me a description of the fight, and it really was very instructive. They were not ill matched as to armament and size, the French ship being rather bigger and higher. They commenced the action, as they thought, out of the Spanish waters, though very close to the edge. They began firing and keeping at a certain distance, going round and round. The French ship found that the German was doing better with his long gun, there was more damage done to the Frenchmen, and he thought it better to ram. In the cloud of smoke which rather blinded the German, the French ship was suddenly seen coming down right at her; the German had just time to port his helm to starboard, and to meet her as directly as he possibly could. The French ship was the higher ship, with an upright stem, and he just avoided meeting stem to stem, but they ground alongside of each other. The German had prepared by laying his guns ready for firing, and desired his men not to fire till he gave the word. As the French ship came alongside in that way, her bow struck the first gun and capsized it; she struck the second gun and turned it aft, so that it could not be fired, leaving the third gun,—I forget whether he said that was fired or not; but the port channels of the German were cut away, the result being that down came the masts and the gear fouled the German's screw. The Frenchman ranged ahead, passing away astern of the German. Both were, comparatively speaking, temporarily disabled; the victory evidently was to the one who would regain the command first. Something happened to the Frenchman, and he was unable first to turn round. The German worked very quickly and cleared his screw, luckily for him, and cut away his wreck. He was then without masts, in the shape of a gunboat, but with steam power efficient to turn round and get his long gun to bear. He hit the French ship two or three times; after one shot there was a burst of steam, and the Frenchman was disabled by a shot through his steam chest or his boiler. The victory then would certainly have been to the German, because he had the moving power and could have taken up any position

he chose. It did so happen that then the Spaniards came out and put an end to the conflict. I mention this instance to show what may be the result of a cannoning. We cannot say who will be disabled, or who will not, but we may be certain that both will have had a very severe shock, which may try them very much before they can turn round and do anything. Now imagine any form of this, and think what shock would take place there, because we must remember our enemies will not stand quietly to let us pass them and attack the sternmost ship, but they will very likely go at us just as much as we would at them, and therefore I think it is that with a second line, whether it is in force astern or in any other way, the victory will be to the second line that comes in and goes at the temporarily disabled ships. If a ship has rammed another and there is time for a consort to come up before she can back astern out of that (and remember how long it is before a ship can get away when she has to back astern from ramming a ship), I think the victory would not always be entirely to the first rammer. It is almost impossible to predict what would be the result of a conflict in that way, unless there is a reserve squadron. And the reserve squadron must not be out of sight at the present day; the reserve squadron must be a second line, but a second line so close as to take advantage of the ramming of the first line. Nobody would detach a squadron out of range, if that squadron is intended to act in the battle at all. It was very well in bygone days, but even if our forefathers could be alive now, their reserve squadron would be within 500 yards, not further than that. I scarcely think the illustration given of the flank movement (Fig. 3) offers a fair argument. We are supposing there that we have caught an enemy in the act of changing front, caught him *in flagrante delicto*. I do not think we have have a right to do that. I think we must suppose that he has been equally on the look out as we have, and if he has been caught so, or if we were caught so, we must conclude we are at a disadvantage. I do not know anything better than for that squadron to turn and ram as fast as they can, but I do not think it would be right to take that as an argument that that squadron is, in the face of this formation, coming at them to try to form a line in that way.

It is difficult to follow perhaps all the rest of the diagrams, but I think I have touched the most material points that have been mentioned. I should sum it all in this, that we really must consider that our enemies, whoever they may be, will be quite as awake as we are to the value of very close order, and ramming as hard as they can. I believe, whether we are unfortunate enough to have to go to war with one nation or another, we should find them equally alive to that, and we must be prepared for that too; and my own impression is that we should have a second line ready to take advantage of the result of the attack of the first.

Commander USBORNE, R.N.: I feel rather a difficulty in addressing this meeting after the very able speech we have listened to, but I think our lecturer has certainly committed the very grievous fault of despising his enemy; I think the enemy who would allow themselves to be caught napping in the way the ships marked A have done, certainly display ignorance of naval tactics. If the rear ship (Fig. 1) had closed up astern, the headmost one ahead of the two wing ships, when the attacking ships passed the blue leader (A) both their flanks must necessarily be momentarily exposed to the bow of the ship which is the second astern, and she might take her choice of either one or the other. If she turned to starboard and rammed the left ship of the pair, then, if the right ship turned to follow her, her flank would be exposed to the left wing ship, and *vice versâ*. That I think was fully pointed out by Sir Henry Codrington. In the right diagram (Fig. 10) I think the ships marked B have placed themselves in a very bad position indeed, and if the ships marked A allowed the enemy to pass between them unscathed, they would deserve all they got. There is certainly nothing in that diagram to prevent the left ships A stopping their engines half a minute. The right ships would be passing a-head of them, and as the ships (B) passed their proper right, they would certainly expose their beam; there is then nothing to prevent the ships A on the left turning to starboard and ramming. And I see no reason to despise a reserve. In all these formations if the ships A had had a reserve, if those B had got at all touched, the reserve would certainly have had them in their own power. And I think we ought not to despise the tactics that were practised by our old admirals; on the contrary, we have a great many lessons to learn from them. The "Nile" undoubtedly was won

by placing two of our own ships to each of the enemy's; it was that that gave us that great battle, and that must be our great object. Naval tactics must always be more or less like a game at chess: you advance in order, but after a very short time, a great deal must be left to the individual captains; and Nelson invariably said he trusted his captains, and that in such cases the captains of ships must be depended upon. Therefore, individual ships and not a group should be the tactical unit. In the case of pairs, what with some of our ships being rams and others not, some turrets and others not, some fast steamers and some slow, some with heavy guns and others with comparatively light guns, it is very difficult indeed to pair ships off so that one could always assist the other. I consider that after the first brunt of the battle, the individual captains must have a great deal of the responsibility upon themselves, but, of course, always subordinate to the Admiral.

Sir HENRY CODRINGTON: I forgot to mention one point about the council of war. I think the lecturer is mistaken as to that. Councils of war are things of such very old date now, that they would be more sedentary councils, not councils in the presence of the enemy. Admiral Lord Nelson took opportunities at sea for collecting his captains, and in conversation showing them what were his ideas of tactics in particular exigencies that might arise at any future time, and, therefore, they were all conversant with the way in which he would act, and therefore, they acted according to his instructions without any signals whatever. That is a very useful thing. But as to anybody having a council of war in the presence of the enemy, it is utterly out of the question, one never dreamt of it certainly.

Captain NEEDHAM, R.M.A.: I feel somewhat out of place in addressing a meeting at which there are present so many distinguished naval officers; but having listened with great interest to the very lucid lecture we have just heard, I should like to ask the gallant lecturer one question. The essence of his system seems to be, that success is to be gained in battles at sea, by two ships acting together in concert, and I wish to ask him whether he really believes that is possible for even so small a number of ships as two thus to act in concert after the battle has once become general? Because I think the history of past battles goes far to justify the presumption that when fleets have once become actually engaged, concerted action between ships is an utter impossibility. If we go back to distant times, to the days of the Romans, we find them fighting with galleys propelled by rowers and armed with spurs and beaks, therefore, on a small scale somewhat similar to the modern steam ram, but we do not find mention of any manœuvring having been attempted with these galleys. When ships fought under sail and with guns for their main weapons, no tactical manœuvres seem to have been carried out, in fact, the characteristic feature of those battles seems that each ship went at the nearest hostile ship and clung tenaciously to it. In the three actions which have been fought between ironclad squadrons, we find that immediately after the action commenced, the battle in all three cases degenerated into a melée. In Admiral Teghetoff's account of the battle of Lissa, he states that immediately after the battle began, the melée became general, and every minute the contest became more confused. He describes the ships as crossing and re-crossing one another so rapidly, that it was almost impossible to distinguish friends from foes; and further on he ascribes the victory partly to the fact that the majority of the Sardinian ironclads were painted grey. It appears to me, therefore, that amid the confusion necessarily attendant upon an action at sea, the commander of every ship would require to devote the most extreme care to prevent his ship being rammed, and to seize any opportunity that might occur for ramming or otherwise injuring an opponent; and, therefore, if his attention is diverted from this task, in order to watch the movements and act in concert with another ship, his own ship would very probably come to grief; and that therefore, although concerted, tactical manœuvres may be of service in order to bring ships advantageously into action, yet that when once the battle has fairly begun, we must trust for success to the possession by our captains of those qualities which have always distinguished English sailors, namely, quickness of decision, promptness of action, and a superior power of giving and taking hard blows.

Captain BRENT, R.N.: I am afraid I must disagree with the lecturer very much; in fact, I disagree with his premises entirely. It seems to me that he wishes that the principles of the signal-book should be that of fighting tactics. Now, the

signal-book, I believe, should be entirely for evolutions; have in it as many evolutions as you can, lay down in it all the formations you think necessary, but the tactics of the battle must rest with the genius of the Admiral. If you make the signal book the fighting basis, you tie your Admiral down, so that he can do but little or nothing, you give him no opportunity of exercising his skill and judgment. If an Admiral chooses to fight in pairs, by all means let him; if he chooses to fight in a square, let him do so; if he chooses to fight in pelotons, by all means let him do so; give him every means of signalling and manœuvring, but the signal-book should not give a fixed and definite form of fighting a battle. It is an evolutionary book with all forms of evolutions for the Admiral to make use of, but the fighting must be left to him alone, as he is responsible for the result. As to this system of pairs, it is to me merely the group system, less one ship and without the power of the senior Officer; the junior may have command at one time, or the senior may have command; you lose the directing power of your senior. In a disciplined service you do not quite look with that respect to the junior that you do to the senior. You lose that, and you have two ships instead of three. It is worse than the group, for the inside broadsides can never be used, but with the group they can use them both. I am not arguing for the group, I do not believe exactly in the group; it may be wanted, I leave that to the Admiral. I do not think we have any knowledge as yet, to enable us to say what will be our fighting formation. We know nothing about it literally, and as far as our signal books are concerned, we can only put in them everything we can think of, to give the Admiral all the power we can. The lecturer said, speaking of No. 1 diagram, as the two ships (B) passed the first ship, they would both fire into her; I should think that would be very dangerous, the chances are you would fire into your friend. As to the rest, I need not say anything after what has been said. With reference to Fig. 2, if I remember right, what Captain Noel said in his book was, that the leader makes a signal for the outside ship to form under cover—he would not leave him out there with two ships away in front—he forms under cover, but you cannot say what they would do exactly. I beg quite to endorse Sir Henry Codrington's remark, that you must allow your opponents to have the same ability, and perhaps better than you have. The formation here (Fig. 5) seems to me to be another very dangerous case, the two second ships are to be left away astern, the two first ships are to go through and then to turn round. You could not suppose the ships marked A would turn round also, seeing an enemy in front and ready to come down upon them, and you would have your own ships advancing towards one another with the enemy between them, and might as likely be rammed by one another as well as by the enemy. I have nothing to say against fighting with two ships, it may be practicable for all I know, our signal books give the Admiral power to do so. As to the council of war, an Admiral who sent for his Captains to discuss with them what he should do, is simply, I should think, incapable. I can understand his sending for his Captains, and saying, "I am going to do so and so, and "you will do so and so," but he does not send for them to ask them what he should do or to take council with them. He would send for his Captains and tell them what they were to do and what he was going to do, and it would be of the greatest importance to know what your Admiral was going to do, for you would then know what to expect under given circumstances and how to act.

Mr. LAUGHTON, M.A., R.N.: You put me, Sir, to a severe trial, in calling on me to address the meeting on such a subject as this, especially after we have heard Sir Henry Codrington and Captain Brent, who speak with authority, as having actually commanded fleets and ships, whilst I know but little about it, except from having read and studied in my own room. I am inclined to differ very much from the lecturer's views, both as to the efficacy of the pair and as to the inefficacy of the group. He speaks of the pair as having unity of action, and as depending for success on that unity; but surely, if, as has been recommended by the advocates of the group system, three ships are carefully and deliberately selected and trained to act together as one, those three, so trained, will be more efficient and more powerful on any given spot than two told off to act together only for the time being. In the proposed attack of the pair against the group, it cannot be supposed that the rear ship of the group would be in the position shown (Fig. 1). Captain Noel has

provided against such a case, and as Captain Brent has just said, she would be under cover of No. 2; the only result of such an attack would be that the port ship (B) as she advanced, would receive three very close broadsides, returning one, or possibly a second, with a hurried and irregular fire; I take it that these three broadsides rattling in, one after the other, would be more than unpleasant. The few shot that escaped her would most likely take her consort, who would be otherwise out of the action. It would, in fact, be a case of one ship getting in amongst three trained to act together, and the one would certainly come to grief. In the case where the ships marked A pass down the ships marked B formed in line a-head (Fig. 6) (supposing an enemy is found so imbecile as to adopt such a formation), the leading ships would, as they pass, receive the broadsides of every ship in the line, so that if it was a long line, by the time they had passed three or four, they would have each had three or four broadsides, and those two ships would be much more inclined to look out for their own safety than to carry out any plan of concentrated attack. Then again, in the very close order of line abreast (Fig. 8), to bring a number of ships against an equal number in the way shown, and to try which has the hardest nose, might be very gallant, and would certainly require a great deal of nerve, but it would not be tactics. There is no tactical skill in meeting an equal force with an equal force; it has been proved over and over again in all history, that meeting ship by ship cannot lead to any decisive result, unless there is great individual difference; that if the forces are really equal, nothing but manœuvring in some way, so as to bring two or three or more ships to bear on one, or a large part on a small part, can possibly be successful. Let the enemy take what form he will, I conceive there is no tactical advantage in attacking him in any way that will not bring the bulk of the attacking force to bear on a small part of the attacked. I think that the formation in groups is the most likely to lead to such a result; I believe that in groups, the fleet can take closer order, when necessary, than in any other mode of formation; and for this reason, that the ships do not, in any way, cover each other; and they can close up from the formation which Captain Noel has prescribed into an order very much closer, still retaining the same bearings; provided that the stem of No. 2 is clear of the one quarter of No. 1, and the stem of No. 3 is well clear of her other quarter, so that any sudden stoppage of No. 1 will not cause a foul; they may be as close as they can possibly pack, without any danger of a collision; twenty or thirty yards clearance, on each side, would, I take it, be enough. Three or four such groups arranged in echelon or triangle, would form a column, which I conceive would be irresistible, if by previous manœuvring it got anywhere near the flank of any enemy in line-abreast; for it would be in very much closer order than any line-abreast can possibly be in. Under such circumstances, I think a reserve would be effective, if the fleet was large enough to allow it. If, for instance, the fleet consists of five or six such pelotons, three or four might form the charging column, whilst the other two or three would form an independent column, manœuvring so as to deter the rest of the enemy's fleet from wheeling round to the support of the attacked wing. I believe it could do that without engaging, but merely by manœuvring, so as to turn its flank if the line wheeled.

Sir Henry Codrington has so well met the idea of the conference, or council of war, that I do not think I need say anything further about it.

The CHAIRMAN: I do not think the lecturer himself insists on that; he is rather opposed to it.

Mr. LAUGHTON: Admiral Jurien de la Gravière, who has been often quoted by our tactical writers, has maintained that one great cause of Lord Nelson's success, was the amiable way in which he held intercourse with his Captains, so that they knew exactly what to do; and I think this is one very strong point in favour of the group system. The commanders of the groups would be Admirals or senior Captains, men probably on intimate and friendly terms with the Admiral, and who in harbour or on previous occasions, would have often discussed these matters over their port wine and walnuts, and be thoroughly acquainted with the Admiral's intentions. If he had to talk it over with 18 or 20 Captains, some of them men of another generation, there would not perhaps be the same friendliness and the same *entente cordiale*.

Lieutenant BOWER, in reply, said: Several allusions were made to this Fig. 1, and the remarks I shall offer in reply will be understood to refer to all those allusions. The first objection raised was, it would be dangerous for the ships marked B to deliver their inside broadsides while passing the leading ship of the enemy. I do not think firing an electrical broadside in this position would be attended with any particular danger to either of the opposite ships, because the distance is so very close that for a shot to miscarry must require a great amount of bungling on the part of, we will presume, the intelligent gunnery Lieutenant who fires the broadside. I was asked if the wing ship turned towards the pair what would happen? In the first place it would be a sufficient answer to that and to all these questions about group formation, to say that no provision whatever is made in our signal-book for all these manœuvres that have been recommended by the various speakers. There is not the slightest mention, nor has any Admiral or group-leader any means of ordering his consorts, or vessels under him, to perform any one of the evolutions recommended by the various speakers. There is no signal that would order those vessels to turn inward. It would require at least a dozen flags to do so. But even were those signals made, and were they willing, it would be a physical impossibility after these two vessels had passed the leader for the two wing ships to do them any damage. A vessel makes, roughly, a circle somewhat over 600 yards in diameter; it is about 700 yards with most vessels; these vessels are moving with the combined speed of twenty knots,—the two fleets,—and if after passing the leading ship, the wing ship of the group were to endeavour to turn and ram the ship marked B, she could not possibly do it. The distance from ship to ship is two cables. I am not prepared to work out a right angled triangle at this moment, but about two cables would be the distance she would have to perform as the diameter of a circle to do so; that would be about 400 yards. It would be quite impossible for this vessel to turn in 200 yards as the half diameter of a circle, at any rate with any of the ordinary ironclads.

I now come to Fig. 2. In this case Captain Brent recommended that the rear-ship should keep under cover, and suggested that Captain Noel points out that the rear-ship could go under cover in such a case; so she could, but she would be quite useless there. Of what use would a third vessel be in such a case? It would require a considerable amount of ingenuity for a vessel of the pairs to place herself across the rear-ship's bow, or in any position capable of being rammed; and it would require a certain amount of ingenuity for the right-hand vessel to place herself so as to be rammed.

Fig. 3 is the flank movement, and I think every evolution in our signal-book ought to be designed for the field of battle. Captain Brent recommends that a large number of evolutions should be included in our signal-book for peace purposes, and that an Admiral should be allowed his option of selecting from them and framing his system of tactics from it. In my system of tactics I have but twelve evolutions; with these 150 formations can be performed, and my argument is that by having but twelve evolutions, and by compelling your Admirals of fleets to use them and no more, you will, when you go on the field of battle have such a proficiency in their execution, and be so thoroughly accustomed to carry them out in every detail, that you are likely to be better up in them than you would if you had a large number, some of them probably practised for the first time on the field of battle. Here we have the flank movement; I show here one of its dangers on the field of battle, and that alone should be sufficient to condemn it. If another evolution will work on the field of battle, then surely that one ought to be preferred to one which will under certain circumstances work, and under others will not, for by practising the one that will work in the field of battle, we surely obtain a better proficiency in it t'nan by practising with two.

In Fig. 6, we come to the case in which Mr. Laughton, I think, pointed out that the vessels would get a certain amount of fire as they pass by. I am speaking of ironclad fleets, and I do not think any vessel will be damaged so far as to prevent her continuing the action, or be damaged in any way as far as her speed and handiness are concerned by the first broadside or two of an enemy. So long as we can keep out shell, or shell with large charges, I do not think we have very much to fear from shot or shell with small charges; and even if a shell does penetrate

the battery and kill a large number of men, I do not know that that in any degree affects the system of tactics; so long as the helm and engines are both able to work, I am quite ready to carry on the fight.

Some of the speakers recommended a reserve squadron, and some speakers pointed out the danger the rear rank in the attack in line-abreast being left to themselves in the rear, while the other two went forward to the attack. Now, these vessels are perhaps a reserve, and it is the only case throughout in which a reserve is employed. When I said I objected to a reserve squadron, I meant a squadron employed as a reserve. I do not call this a reserve at all; anything within 300 yards of the enemy cannot be called a reserve. The danger was pointed out of dividing your fleet in this way, and at the same time the same speakers recommended the employment of reserve squadrons. Surely this is an inconsistency. If it is dangerous to divide your fleet, surely it is dangerous to employ a reserve squadron under any circumstances whatever.

Now about the cannoning. Mr. Laughton pointed out that there is no advantage to be gained here. No more there is; there is no tactical advantage, and I do not see how tactical advantage could be gained in any way. I only point out the only means, not of gaining a tactical advantage, but of saving yourself. Were any other means adopted, certain disaster must ensue, because a large force will be brought to bear against a portion of the enemy's line.

Mr. Laughton made a few remarks also on groups, which I should like to notice. He says he has studied groups in his own room. I can see no reason why he should not study groups as well in his own room as elsewhere. Every formation that an enemy is capable of assuming is limited. There are only certain mathematical figures that he can use; modifications of the triangle, straight lines, or a circle; and, as he can consider every one of these forms, so he can consider the forms to be used to defeat them; and, in my system of tactics, I endeavour to point out precisely what is expected of every ship, and what the object they are to aim at. Should circumstances arise that prevent them carrying out their object well, a unit composed of two ships is not so large as to be unwieldy or to prevent communication between one and the other.

Admiral Codrington objected to my taking away the command from the senior Officer. I suppose in this case (Fig. 5) the leader of right column is to be the Admiral, No. 2 in port-column is to be the second senior Officer. During the whole time of passing along the line, these vessels are shut out from the view of the Admiral, and cannot see the Admiral, but the ships of pairs can communicate, should there be anything to require any alteration in their conduct.

Mr. Laughton pointed out the advantage to be gained by groups in close formation in attacking the wing of an enemy. But he has first to get to the wing of an enemy, and a group is so difficult to maintain in action; it requires the use of compasses, and it is so difficult even in the closest order to maintain, that I do not think it could last long. By my system there are no compasses required. You do not steer by your Admiral, but only by your enemy; every ship has a distinct duty to perform and steers only for her enemy. Mr. Laughton reminds me very much of a man who takes a spade to saw wood. He has pointed out how groups can be easily manœuvred in close order and in various ways; and he has then fallen in love with his group, and takes it to the field of battle, and expects it to do wonders. But on a field of battle his group will not fight, and that is the one object for which the British Fleet is designed; and, unless the evolutions are designed to meet the varying conditions of a field of battle they are useless for our purpose. I do not know that there is anything else that I have to notice. The remarks offered were so extensive, I am afraid I have not been able to take notice of all of them. Captain Needham recommends that we should trust to seamanship, but surely we best learn seamanship and confidence in a field of battle by knowing what we are going to do before we get there.

The CHAIRMAN: As there is another paper, or rather an explanation to be given of the model before us by Major Innes, I will ask the meeting to return their thanks to Lieutenant Bower for his interesting and able paper. He has brought before us a subject of the greatest interest to naval Officers, but I think, from what we have heard to-night, we may conclude that a great many actions will have to be fought

before we can arrive at any very definite conclusions with regard to the tactics of the future. The whole subject is one of great novelty and full of difficulty, including the questions of ramming, of torpedoes, of guns, and speeds of ships, and of the circles in which they can turn, and so on. The question chiefly before us to-night has been whether a group of three ships or a group of two ships is the best formation for fighting. It is quite evident if you can bring the three ships to bear upon one they will probably do her more damage than the two. One thing has been very satisfactory to me, to learn, on the authority of Lieutenant Bower, that our gunnery practice has arrived at that degree of accuracy that two ships can pass an enemy's ship, leaving her between them at the rate of twenty knots, for they are each going ten knots in different directions, and that every shot from the two ships will be sure to hit the enemy's ships between them and not miss her, and thus damage each other. Assuming on his authority such to be the case, it certainly shows what a great advance has been made during the last few years in the practice of naval gunnery. I beg to return to Lieutenant Bower our very cordial thanks for a most interesting paper.

NOTE.

FIG. 1.

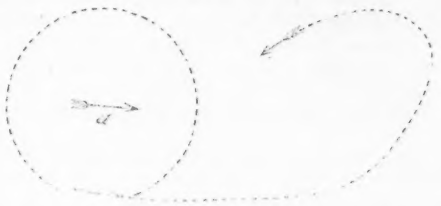


FIG. 2.

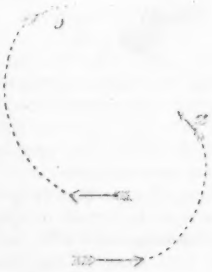


FIG. 3.



As it would seem from the discussion on my lecture, that some misapprehension exists as to the properties of the inner circle that enables me to disregard the movements of the wing ships, in my attack on groups, I would make the following explanation of them.

In Fig. 1 I have illustrated the first application of the principles. It is evident that there exists a position in which (*a*) may rest relatively to (*b*) in security, that (*b*), in order to ram (*a*), will have to steam off at a tangent to the circle, then turn and charge.

In Fig. 2 this principle is applied to two ships meeting; here (*a*) and (*b*) are meeting, (*a*) turns to port, (*b*) to starboard, the result being that (*a*) finds himself on the inner circle as regards (*b*), and in safety, (*b*), being on the outer circle, is in danger.

Fig. 3 is a further extension of the same, and applied to illustrate the sternmost position, which is one always on the inner circle.

Now, in the attacks on groups shown in my lecture, the pairs are in safety, and on the inner circle with reference to the wing ships, directly they pass the leading ships of groups.

The attacks in line-abreast are applications of Fig. 3, and endeavour to utilise the sternmost position.

In considering all tactical diagrams, motion on the course must be counted as double motion normal to the course.

As the safety of discharging the inside broadsides of the pair in Fig. 1 has been doubted, I would submit the following for consideration.

The guns of most of our modern ironclads are concentrated amidships; assuming that the length of battery is equal to 100 feet, distance of ships apart = 50 yards, total length of ship = 300 feet, we have the limiting error admissible for foremost and after guns = $\tan.^{-1}\frac{1}{3}$. Whether an electric broadside can be discharged within these wide limits can only be determined by experience; but whether it can or not, it must be remembered, that if dangerous for the pair, it is equally dangerous for the wing ships of the group.—G. B.

SELF-ACTING GUN-CARRIAGE WITH ELEVATING MANTELET.

By Major Alexander Innes, Aberdeen Artillery Volunteers.

This model of a self-acting gun-carriage has been constructed to illustrate a new and original method of dealing with the requirements of modern gunnery, involving the working of guns of unprecedented power, weight, and magnitude. But, before attempting to go into the technical details of the model, I propose lightly to sketch its origin, and the objects in view for the construction of its several parts.

Let it be supposed that an emergency has arisen, that certain points in a line of coast defence are threatened, and have to be armed on the shortest notice with heavy guns, where little or perhaps no effectual works of defence exist; that a gun is required that shall be capable of sustaining and returning opposing fire whether vertical or horizontal, and whose carriage, mode of mounting, &c., shall possess in their construction effectual shelter and adequate security for its ammunition and detachment; that it shall possess an improved rammer, which shall secure the most rapid and effectual means of loading and sponging, with a laying and sighting apparatus to enable the laying of the gun to proceed simultaneously with the loading.

The subject thus seems to divide itself into three problems, namely,

the best method of receiving the impact of the opposing projectiles; the most compact and expeditious system of sponging and ramming home the ammunition, with provision for its safe supply and working for the gunners; and improved method of sighting, for bringing the gun into alignment and range, so as to be found in immediate collimation when run up to the firing position.

To meet the first requirement (in the absence of regular works), the only shield likely to divert a projectile from its mark, and to receive with impunity the effects of the blow, seems to be wrought-iron, of well-proportioned strength, weight, and thickness, but, above all, of convenient form and nature of suspension so as to absorb and reflect the force and effect of the impact of projectile.

To illustrate this, we may refer to the well-known feat of supposed strength for a man to sustain the heaviest blows from a sledge-hammer (which would otherwise prove his destruction) on an anvil placed and supported on his breast while lying horizontally between two stools or supports.

In providing for the second it is obvious that any defence of the nature of an elevating shield in front of the gun, necessarily so close as to cover the gun from the effect of vertical fire, when in the act of loading, must necessitate a very compact apparatus of certain and easy application. That this may be accomplished in various ways I do not doubt, but I have not yet met with a substitute for that employed in the model.

Lastly, the value of ammunition and projectiles for present and projected weights and calibres of guns is so great that any method securing accuracy of line and elevation for range must prove a valuable attribute for ordinary practice, but how much more in actual service, when rapidity of fire on moving objects becomes of the first importance.

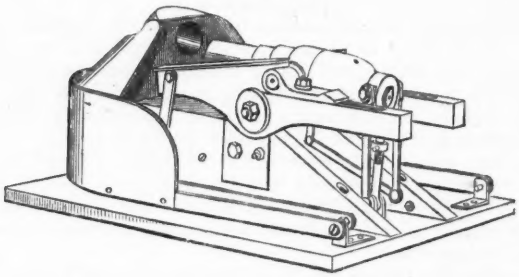
Turning now to the model, the first principles of which I sketched out a dozen years ago, and the soundness of which seem demonstrated by their closer application to the apparent wants and defects in the working of the new heavy guns of position, I would not have it supposed that I presume to discuss, much less to condemn, the existing system of batteries and fortifications, or to go into the rival questions of breech-loading and muzzle-loading. I only venture to assume that a gun of this nature may be placed and hold its own in a position unapproachable in present recognized systems of fortification which require time and capabilities of ground for their execution, and which find their places most accurately on the plans of the enemy when rapidity and secrecy in preparing for defence, present the first elements and prospects of success. This gun, however, requires nothing beyond a level surface to sustain its platform, as it provides for itself all necessary cover and protection.

The model as first presented to view (Fig. 1), mounted on its cone turntable,[1] is in the firing position. On being discharged, in consequence of the balance-cheeks being blocked up (they are removed in the sketches), the gun on its recoil produces no other effect on the

[1] The cone turntable is not shown in the accompanying sketches.

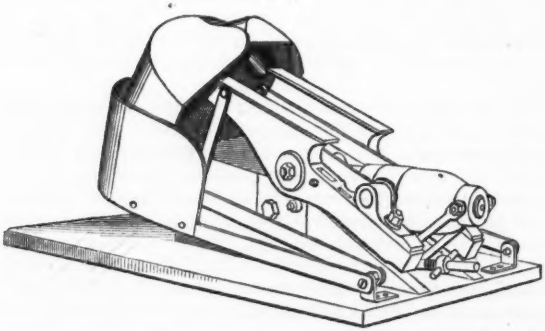
mantelet than is necessary to absorb the effect of the recoil, provision being made in this manner for working the gun should the elevating action of the mantelet be thrown out of gear.

FIG. 1.



In order to increase the cover, and to secure the operation of loading from the effect of vertical fire, it will be seen that on the blocks being removed when the gun has run back under the effect of the recoil, the mantelet will rise in any proportion that may be desired, and the gun subside into the loading position (Fig. 2).

FIG. 2.



Having now come to its bearings, the muzzle of the gun is found to drop into position to receive in succession the sponge and lubricator, upon which it takes a slight elevation on turning on the trunnions and receives the charge and projectile, dropping again to be rammed home and returned to the firing position.

The rammer is constructed of an interior and exterior tubular arch of metal, so divided as to coil round a toothed wheel, and is made to deliver the sponge, lubricator, and rammer heads in succession down the bore of the gun, and last, not least in importance, to keep down the

temperature of the gun by a copious supply of water delivered in the chamber of the gun.

In the model, the action of the mantelet and its distance from the muzzle have been *designedly exaggerated* in order to give the best opportunity to examine the apparatus for taking up the recoil; but it is evident that in a practical adaptation, this would be reduced to a minimum for the security of the ammunition, the gun, and the detachment.

The thanks of the meeting were then voted to Major Innes, for submitting the model of his carriage for the consideration of the members.

PLAN FOR PROTECTING SHIPS (AT ANCHOR), BLOCKADING A PORT FROM ATTACKS BY OUTRIGGER WHITEHEAD, OR HARVEY TORPEDOES.

By Lieutenant Charles Lindsay, R.N.

The mode of conducting naval warfare has undergone great changes in, so to speak, late years, through the introduction of torpedoes. This new weapon being unseen, and taking effect under water, is all the more difficult to guard against. Hidden enemies being always the most dreaded, the moral effect is very great; so much so that a fleet was kept off a port, in the late war, by a harbour protected by dummy torpedoes. When the torpedoes arrived, the burgomaster was afraid to charge them, but laid them out empty. And at the completion of the war, when the dummies were taken up, the burgomaster was congratulated by several consuls on the masterly way in which it had been performed, no loss of life having been caused in the task—really a most dangerous one, as we know that after the American war, at Charleston, where the same men who laid them down took up the mechanical torpedoes there was great loss of life.

Many attempts have been made to protect ships against this hidden foe, by increasing the number of compartments and by giving ships double bottoms.

But the subject I wish particularly to treat of, is guarding ships against offensive torpedoes, viz., the Whitehead, the Harvey, and the Outrigger.

In 1873, the "Monarch" was protected against the two latter descriptions, under the superintendence of the Naval Torpedo Committee, by her own spars and stores; but as the "Monarch" had been only temporarily commissioned for the visit of the Shah, and had not her stores on board, she was supplied by the dockyard with what were called her own stores. She used her topmasts, trysail masts, and longest spars; round these spars were hawsers, at various distances from the ship's side, of wire and rope, and from bow and quarter-spars were hung grapnels. This took about a week to get ready, but it was said that it could be done by a ship, with her own spars and stores, in twenty-four hours.

This protection will be seen at a glance was useless against the Whitehead, as we know that it can be set to go at a certain distance under water, therefore obstructions on the surface were of no avail.

The ship was partially protected against the Harvey by the grapnels,

PLAN FOR PROTECTING SHIPS (AT ANCHOR) BLOCKADING A PORT, FR

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Fig 1.

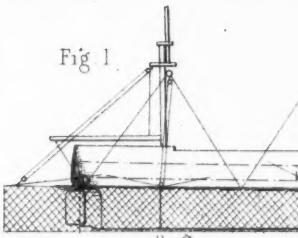
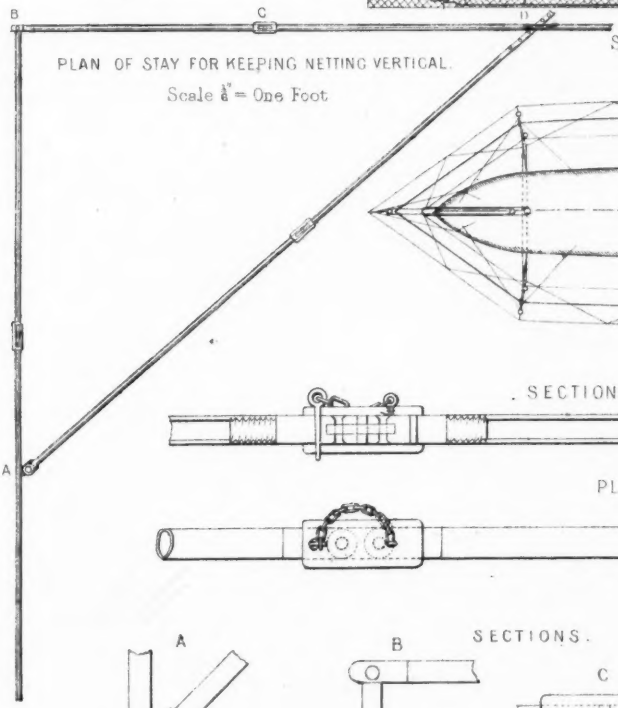


Fig. 5



PLAN OF STAY FOR KEEPING NETTING VERTICAL.

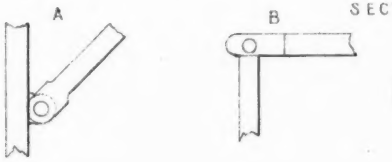
Scale 1" = One Foot

Scale

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PLAN

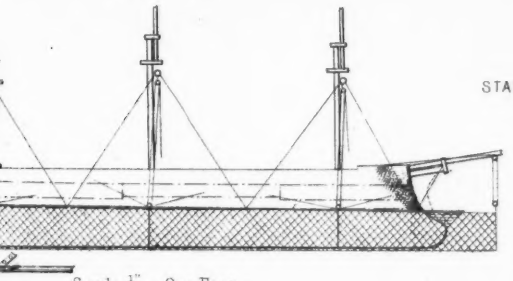
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G A·PORT, FROM ATTACKS BY OUTRIGGER, WHITEHEAD OR HARVEY TORPEDOES.

CHARLES LINDSAY,
LIEUT R N.

ELEVATION.



Scale $\frac{1}{36}$" = One Foot.

PLAN

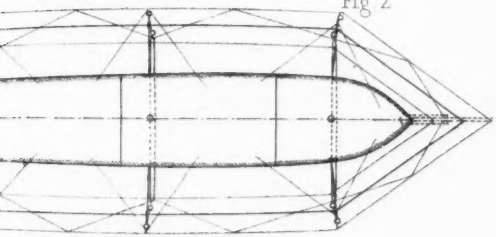
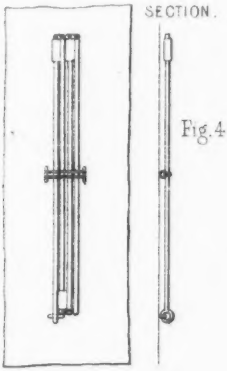


Fig 2.

STAYS STOWED AT SHIPS SIDE.
Scale $\frac{1}{8}$" = One Foot.



SECTION.

Fig.4

ECTION OF OUTRIGGER. Scale, 1" = One Foot



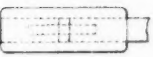
PLAN OF OUTRIGGER.

Fig 3.

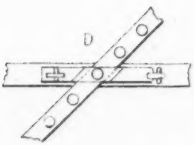


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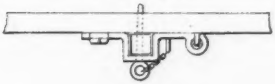
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PLAN AT D.



for a gun-boat tried to strike the ship in passing, but once only the levers were pressed down. However, if the "Monarch" were to come up astern, to ram a ship with the Harvey placed astern or on the quarter, and hung like a life-buoy, as proposed, the object being to use it on the defensive, she (the "Monarch") would have no protection against this application of the Harvey.

The Outrigger torpedo was tried in a steam pinnace. The ship had steam up, and slipped on a given signal. The pinnace came at her from some distance ahead, and was very nearly capsized by the hawsers, but was near enough to have exploded the torpedo in contact, or very near it.

The want of a protection of some sort for ships was evident in the last war, where a whole fleet was incapable of acting through fear of torpedoes. The French Fleet had to steam out to sea every night, to avoid outrigger torpedo-boats, and when they came in next day, it was almost time to start again. What evidently was required, then, was a more perfect protection, which could be quickly got out and in, allowing the ship to keep under weigh, moving slowly, if necessary, as in blockading a port.

I forwarded a plan to the Lords Commissioners of the Admiralty for this purpose—a wire netting, equal in depth to the draught of water of the ship, completely surrounding her. This was hung from iron-jointed outriggers, three on each side and one astern, the jibboom answering that purpose ahead. There were four joints in each outrigger, of flat iron, each joint ten feet. The Committee had made forty feet, a *sine qua non*. I endeavoured to find out the reason, but failed. I think that a less distance would do, especially as the "Oberon" experiments have clearly shown at what close proximity the charge must be to do any damage to the bottom of the vessel. These outriggers were supported by topping lifts and guys, and could be triced up or lowered, the mode of supporting them being merely a matter of seamanship; and, when not in use, they were fitted to fold up and stowed perpendicularly against the ship's side, and secured by lashings. The netting was rolled up and stowed in boom-boats amidships, so that it could be hoisted out with them and run round the ship, in an hour at most, the outriggers being got out and unfolded by another boat, as will be more fully described further on.

The Committee found fault with this plan on account of the non-rigidity of the outriggers and their insufficient number and strength (the two latter being merely a matter of detail), and they did not think it so good as a plan of their own, which they brought out about the same time. In their plan, which was tried on Her Majesty's ship "Glatton," the net was the same as above described, but hung by ship's spars, and was supposed to be got ready in twenty-four hours. The net flapped up under the bottom, with a tide about three or four knots, or moving ahead at that rate, when the net flapped up, the side was unprotected from the Whitehead, and the vessel was excessively unhandy, owing to the complicated arrangements. She was considered successfully protected against a boat, but not a gun-boat using an outrigger, as gun-boats of the "Comet" class are to be fitted with.

I proceeded to remedy the faults in my former plan, and trust I have successfully done so in the annexed diagram.

Fig. I is an elevation, showing an iron-clad ship (Her Majesty's ship "Bellerophon") with the wire netting hung by three-jointed outriggers, one on each side, one astern, and by jibboom ahead.

Fig. II is a plan showing outriggers in four lengths of ten feet each, made of gas piping (gas piping being used on account of great strength, lightness, and cheapness), supported by topping lifts from yardarms, guys, &c. The netting is supported between the outriggers by a span from yardarms, which, with the topping lifts, would enable the netting to be triced up, to effectually prevent any attempt to override them by outrigger boats. A wire rope goes round the ship, about ten feet from the netting, and a hawser ten feet inside that; these are a further support to outriggers, also a further protection against outrigger boats.

Fig. III is a section of a length of outrigger, showing the joint, the ends being tapped to receive solid metal plugs, through which pins are placed that the tongue works on, and allows them to turn up when not in use. The tubing which goes over the joint keeps the outrigger rigid, and when the outrigger is not in use, the tubing is pushed back and the pin put in, to keep it in place, as shown in Fig. IV of outrigger stowed for sea.

Fig. V shows the stay for keeping the netting perpendicular. The rod B A is small and solid, and goes in and out of different meshes, as shown in Fig. I. A D is the same size as B A, and works as shown in Fig. IV. B C D is the ordinary outrigger of gas piping, but is shown small and same size as B A and A D, to show the idea more clearly.

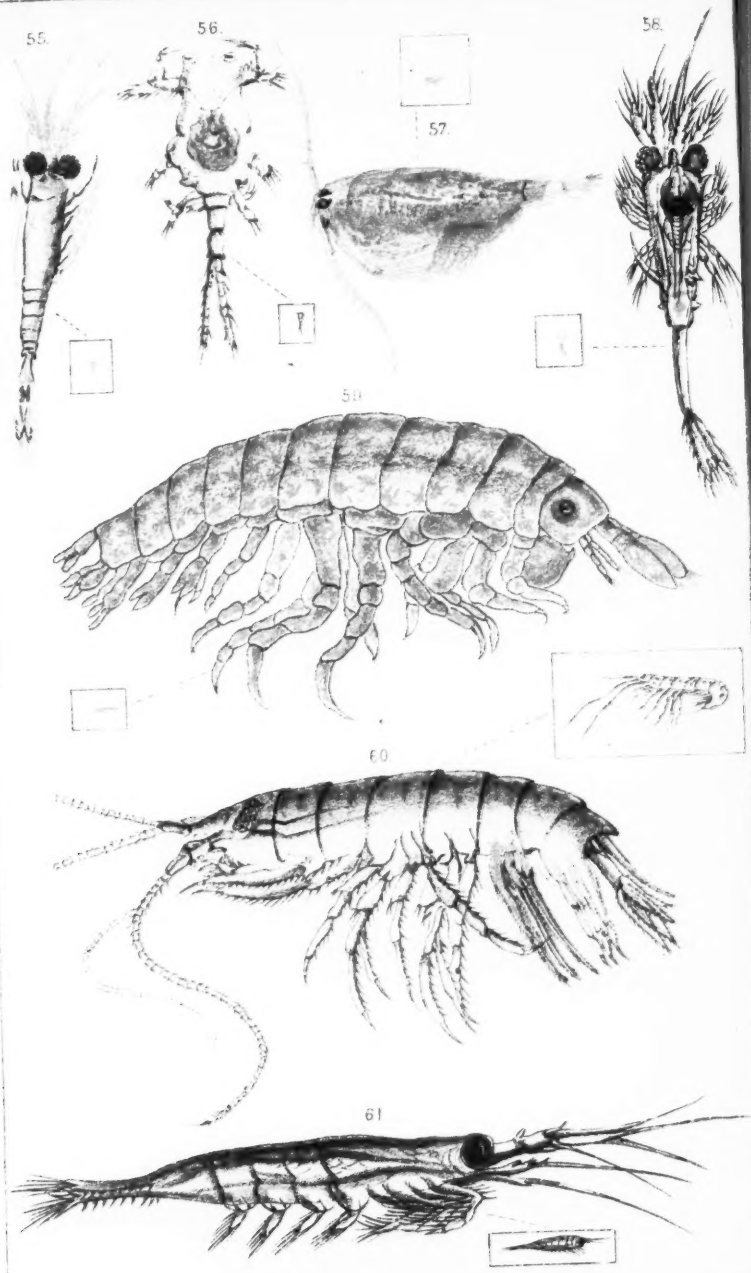
This gets over the failure in Her Majesty's ship "Glatton," of the net flapping up under the bottom.

A Whitehead torpedo striking this netting will explode, and merely damage the net at that place. This has been found out by actual experiment.

When the ship is at sea and outriggers are not in use, they are folded up and lashed against the ship's side, as in Fig. III. They would not be in the way or unsightly.

The netting, which is the same depth as the draught of the ship (certainly not more than 28 or 29 feet), would be rolled up in lengths, as convenient. The netting for each side of the ship being in two lengths, would probably suit best for a large ship, the diameter of the roll for 50 yards being about 18 inches. These rolls I propose stowing two in each boom-boat amidships, the length of the roll being 12 to 15 feet less than the length of the boat, they could be stowed easily.

On arriving off an enemy's port, and wishing to remain under weigh for blockading or other purposes, the boom-boats would be hoisted out and netting run round the ship; another boat each side assisting to place the outriggers and secure the netting to them. The boats would then be hoisted in again, and the ship steam slowly (from three to four knots at least), as required. The anchor might be let go, if necessary, and guard-boats placed round the ship. It would be


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advisable to have "service hand-charges" and other appliances suitable to the situation in them, which would effectually dispose of any of the enemy's boats that approached.

The ship ought also to have several 20-pound Armstrong's, loaded with case, and given extreme depression, so as to strike the water at about the end of outriggers; these guns should be kept loaded.

When required to go to sea, the boats will be hoisted out, the netting got in, and the outriggers secured, as already described. It would certainly not take more than one hour to rig and half-an-hour to unrig.

DELINEATIONS OF SOME MINUTE SEA-SURFACE ANIMALS.—From Coloured Drawings by Mrs. TOYNBEE.

PART III.

(*Continued from page* 379.)

For instructions regarding means of capture, examination, &c., see page 214.

PLATE V.

Fig. 55. April 23rd, 1857. Lat., 23.29 S.; long., 3.33 E. Temperature of surface water, 67°. This larva crustacean was taken by the net from a very phosphorescent sea, but died before it could be examined.

„ 56. March 6th, 1857. Lat., 0.57 S.; long., 82.49 E. Current, N., 30 E., 25 miles. Temperature of surface water, 81°. *Copilia mirabilis.* The striped claw on each horn was very distinct.

„ 57. *Anomalocera, Crustacea, Copepoda.*—March 28th, 1857. Lat., 29.22 S.; long., 44.55 E. Current, S. 74 W., 5 miles. Temperature of surface water, 73.9°. The eyes appeared to be multiplex, and the circles on them moved regularly to and fro like a piece of machinery.

„ 58. *Larva?*—No description.

„ 59. *Crustacea, Amphipoda.*—Nov. 13th, 1856. Lat., 32.42 S.; long. 76.19 E. Temperature of surface water, 62°. Crustacean found in a jelly fish. It appeared to respire by a quick movement of the hind legs. In the legs there was a distinct circulation of a colourless fluid containing a few corpuscles, the fluid running down one side of the leg and up the other.

„ 60. *Crustacea Amphipoda.*—April 17th, 1857. Lat., 31.13 S.; long., 13.18 E. Current, N. 65 W., 7 miles. Temperature of surface water, 63°. Pumped up this shrimp, as it may be called; it was probably brought by the northerly current into the deep sea.

„ 61. *Larval Crustacean.*—Jan. 9th Lat., 16.18½ N.; long., 82.22 E. Temperature of surface water, 75.5°. This was caught in the bucket from about a depth of ten fathoms. It kept its legs in very rapid motion. Its eyes were multiple, it does not seem to belong to the deep sea.

PLATE VI.

„ 62. *Larval Holothurioid?*—May 17th, 1858. Lat., 35.26 S.; long., 18.40 E. Current, N. 78 E., 2 miles. Temperature of surface water, 65.3°.

Caught two of these larvæ in the bucket; in both were detected wings as they flapped quickly through the water, though when placed under the microscope there was no sign of them; nothing was in motion save the active ciliæ and the incessant contraction and expansion of the flexible body, especially at the upper end.

Fig. 63-4. April 9th, 1857. Lat., 34.59 S.; long., 19.55 E. Current, S. 64 W., 14 miles. Temperature of surface water, 64°. Caught this holothuria? in the net, besides numerous crustaceæ. Its first appearance was cup-shaped, as in Fig. 63, then changed its form by projecting its mouth as in Fig. 64; after working it actively for some time with a kind of sucking motion, it drew itself into a ball and died.

„ 65. Oct. 6th, 1857. Lat., 12.06 N.; long., 26.49 W. Current, N. 49 W., 28 miles. Temperature of surface water, 80°. Nearly calm; caught two. The ciliæ and long feelers were kept in very active motion, and the sucker-like mouth contracted and expanded.

„ 66. *Phyllozoa?*—Dec. 14th, 1857. Lat., 9.35 S.; long., 82.47 E. Current, S. 66 W., 24 miles. Temperature of surface water, 81°. The side paddles of this annelid all seemed to consist of two pieces as shown in enlarged drawing.

„ 67. *Monosomatomatous Worm?*—Nov. 23rd. Found this worm, which swam freely in the water, though when placed in a drop of water under the microscope it was very quiet.

„ 68. *Annelida, new form?*—March 9th, 1857. Lat., 7.35 S.; long., 84.11 E. Current, N. 45 E., 17 miles. Temperature of surface water, 80.4°. This annelid moved through the water with a wriggling motion, moving its fins rapidly.

„ 69. *Annelid Larva.*—April 9th, 1858. Lat., 12.48 S.; long., 74.30 E. Current, N. 24 W., 17 miles. Temperature of surface water, 81.2°. This larva was very active, darting about and working its ciliæ. When under the microscope there was no trace of internal formation, eyes or mouth, the whole looked one soft contractile, elastic mass.

„ 70. No description.

„ 71. Dec. 26th, 1857. Lat., 1.05 S.; long., 85.13 E. Current in two days, S. 73 E., 58 miles. Temperature of surface water, 81°. Caught this creature which moved about its large mouth, contracting and expanding its body, the dark mark on the body looked raised and hard.

„ 72. Dec. 24th, 1857. Lat., 4.03 S.; long., 82.11 E. Current, S. 25 E., 19 miles. Temperature of surface water, 80.9°. Found this shell; it was very light, floating on the top of the water.

„ 73. *Macgillivrayia, or Cheletropis.*—April 27th, 1858. Lat., 29.30½ S.; long., 45.32 E. Current, S. 42 E., 9 miles. Temperature of surface water, 76.7°.

„ 74. April 22nd, 1858. Lat., 27.29 S.; long., 52.51 E. Current, N. 2 E., 22 miles. Temperature of surface water, 75.1°. This delicate little medusa worked its crown of ciliæ actively.

